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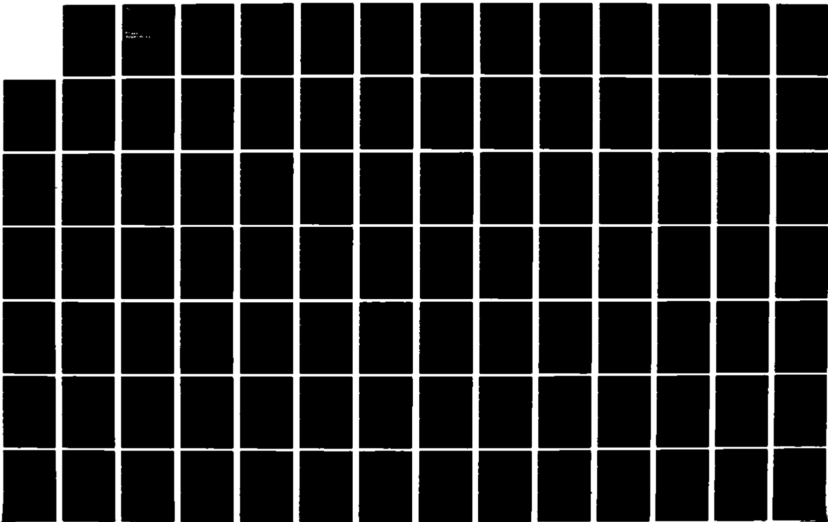

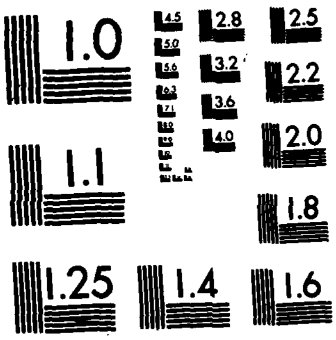

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US Army Corps
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Baltimore District

Chesapeake Bay Low Freshwater Inflow Study
Biota Assessment

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Phase I
Appendices

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Prepared for
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by Western Eco-Systems Technology, Inc.

August 1980

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Phase I of this report consists of a 2-volume report plus one appendix containing species tolerance and habitat information.

Phase II consists of a one-volume report and a supplementary MAP FOLIO.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chesapeake Bay, Biology, Salinity, Habitat, Estuary

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An assessment of the effects of low freshwater inflow conditions on the biota of Chesapeake Bay was conducted through use of data output from the U.S. Army Corps of Engineers' Chesapeake Bay Hydraulic Model. Phase I of the biota assessment focussed on methodology development and establishment of a baseline for determination of freshwater inflow-induced change. Physical and chemical information, along with salinity tolerance and other habitat related information was collected for a group of over 50 study organisms.
(SEE REVERSE)

20. ABSTRACT (continued)

In Phase II of the assessment, four sets of hydraulic model test conditions (scenarios) were used which simulated effects of drought and effects of future consumptive water use as deviations from present average flow conditions. Changes in habitat for the selected study organisms were predicted and mapped based on salinity and other variables. Changes in habitat, which were used to delineate the amount of impact from reduced freshwater inflow, were found to include increases and decreases depending on the species, its lifecycle, tolerances, and interactions with other organisms. The magnitude of habitat change was found to generally increase as salinity changes increased.

CHESAPEAKE BAY LOW FLOW STUDY:

BIOTA ASSESSMENT

PHASE I: FINAL REPORT

VOLUME III

APPENDICES

August 1980

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This document is the result of studies by Western Ecosystems Technology, Inc. and represents the judgements and conclusions of the authors. It does not necessarily reflect the opinions of the U.S. Army Corps of Engineers.

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- National History Museum
- Chesapeake Bay Center

Old Dominion University

The American University

Virginia Institute of Marine Science

Virginia Marine Resources Commission

Virginia Fish and Game

National Marine Fisheries Service

- Resource Statistics Division
- Oxford Laboratory

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2. Predation on benthic organisms in lower Bay.
3. EPA upper Bay benthic survey.
4. EPA Potomac River benthic survey.
5. Response of organisms to chlorine stress.
6. Distribution of diatoms in Patuxent River.
7. Phytoplankton distribution vicinity of Cape Charles on the ocean side.
8. Bay wide distribution of tintinnids.
9. Distribution of dinoflagellates with respect to fronts; productivity and nutrients in vicinity of fronts.
10. Zooplankton distribution in lower Bay.
11. Macrofauna distribution with respect to sediment size.
12. Benthic infauna and sediment chemistry survey.
13. Plankton response to herbicides.
14. A microcosm model relating SAV's and benthic invertebrates.
15. Saltwater intrusion along the Gulf of Mexico coastline.
16. Effects of herbicides on SAV's.
17. Thermal effects on zooplankton.
18. The effect of hydrographic conditions on the distribution of blue crab larvae in the area of the mouth of Chesapeake Bay.

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Selected Studies Completed - Not Yet Published

1. BLM southern Atlantic shelf-zooplankton distribution.
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8. Genetics of temperature tolerance in copepods.
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APPENDIX B

MAP APPENDIX AND
SPECIES DESCRIPTIONS

INTRODUCTION TO MAP APPENDIX

The products developed in Phase I include a map-atlas of study species distributions under defined base conditions generated on 1:250,000 scale mylar base baps and overlays and submitted to the Corps of Engineers. This appendix summarizes the criteria used in mapping each of the "study species" (see Table B-1) and, in addition describes important aspects of the species tolerances to salinity and other factors.

Mapping of the Chesapeake Bay Biota is predicted on an understanding of the habitat requirements of a set of organisms designated "study species". Definition of habitat requirements and the classification of habitat into consistant mappable units is described in detail in Volume I of the final report of Phase I of the Biota Assessment. The following applicable salinity subdivisions were delineated:

Limnetic (Tidal Fresh Water)	0.0-0.5 ‰
Oligohaline	0.5-5.0
Mesohaline	5.0-18.0
Polyhaline	18.0-30.0
Euhaline	over 30.0

This is the "Venice System" widely used both here and abroad to characterize estuarine environments, including those of Chesapeake Bay. This system has been modified to include an upper and lower mesohaline zone, separated at 10‰.

Because the entire Bay has not been completely surveyed for every study species, it is necessary to deal with an organism's habitat from two perspectives. These concepts are: *known habitat* - where an organism has actually been found to exist, and *potential habitat* - where, judging from life history data and known tolerances to stress, conditions are suitable for the organism's existence (see Figure IV-17).

Minor corrections were occasionally made to standardize known distribution and known habitat to salinity zones and substrate regions, since organisms are sometimes displaced into an area where they would not normally be found (such as a fresh water fish being carried into brackish water by a flood). Literature on the distribution of nekton with respect to salinity was carefully cross-checked to determine if suspect capture records were outside a species normal range. Definition of habitat for nekton reflects the organism's normal distribution, but not necessarily all recorded catch locations. Where the literature reported both the species tolerance range and the species preference range, it is the species preference which is mapped with respect to salinity. Few species have previously been mapped (in detail) on a Bay-wide basis, yet the inter-relationships of the physical structure of the estuary with the biota stand out most clearly when seen from this perspective. Therefore, the decision was made to map each species on a sheet showing the entire Bay.

Maps were prepared using shading films and ink or tape lines indicating differing zones or distributional patterns. In many cases, an ecological understanding of the distribution entailed considerations of factors such as seasonality, spawning or nursery areas of specialized lifecycle stages. These have been mapped wherever data permits.

The maps have been compiled into an oversized (33" X 54") map atlas, complete with indices and keys, which is to be on-file at the Corps of Engineers Baltimore District. This document may also be placed on-file at other reference libraries; beyond the above, distribution of the map atlas has not been decided at this time.

1. Salinity Base Year

In order to understand why a particular year was selected as representing physical baseline conditions the concepts of a

Water year must be defined. A graph of inflow will shown an approximate sinusoidal curve to the mean monthly inflow, which peak in March or April, reaching its low point in September. *Water years* are defined as the inflow pattern from October 1 - September 30 of the following calendar year. The U.S. Army Corps of Engineers uses the water year as the base for the Chesapeake Bay Hydraulic Model.

The specification of a reference salinity pattern is complicated by the changes due to tide, storms, and seasonal variations in run-off. The Salinity Atlases produced by Johns Hopkins Chesapeake Bay Institute, provide a picture of seasonal and annual variations in salinity in the main stem of the Bay on the same stage of the tide. Averages have been derived from these salinity distributions. However, the averages include the low flow years and to use them would have the effect of partly masking the event we are trying to detect from the baseline. The mid-point of flow for the period 1950 - 1979 is about 75,000 cubic feet per second (cfs). The period closest to this median point is the period 1960 - 1962. The second year of this period was chosen for use as an average flow year for Phase I of the Biota Assessment on the assumption that the second in a series of "average" years would be the most free from historical effects of a previous anomalous flow. For mapping purposes, Water year 1960 (October 1960 to September 1961) salinities are used to define "average salinity" conditions.

2. Habitat Description Factors

Using both the Chesapeake Bay Salinity Atlas (Stroup and Lynn 1963) and the Chesapeake Bay Oceanographic Data Base (Maryland Tidewater Administration, Borman 1974), isohalines were plotted for the 1960 - 1961 Water year at depths of 0, 10, and 20 feet (approximately 0, 3, and 6 meters) for the following time periods:

Spring	March - May, 1961
Summer	June - August, 1961
Autumn	Sept. - Nov., 1961

Winter isohalines were found not to be available for the Base Year from the Salinity Atlas. Where necessary, late fall salinity distributions were substituted for the missing winter salinity values. The Salinity Atlas isohalines were derived principally from longitudinal sampling runs up the mainstem of the Bay following the same slack water phase of the tidal cycle. Tributary data is sparse in the Salinity Atlas and will be filled as much as possible from the Chesapeake Bay Oceanographic Data Base which contains results of many separate studies. The tributary data differ from the mainstem data in that all the observations were not collected at the same stage of the tide. Local studies may give clear definition of the salinity distribution for only short stretches of a given tributary. Where the needed isohaline values were not found within the regions studied the needed isohalines were produced by extrapolation between regions of known values. This adds additional uncertainty in some of the tributaries because adjacent blocks of data to the extrapolated region may have been taken at different (and unknown) stages of the tide and river flow.

For mapping of habitat requirements we have expanded the Venice System to include factors other than salinity, particularly substrate, depth, and seasonality. Base maps have been prepared for each of these parameters and these base maps have served as the basis for species mapping as defined in Table B-1.

Substrate: Sediments have been mapped on a relatively simple four-category classification system of sand, muddy sand, sandy mud, and mud. Current programs are underway at both the Maryland Geological Survey and the Virginia Institute of Marine Science for updated sediment analyses of the Bay mainstem; however, these data are not yet available. The updated surveys are expected to give more detailed information on sediments, including particle grain size and geochemical profile information.

These data should be available during 1980 for Phase II of Biot Assessment.

Depth: Depth has been used as a habitat modifier only with respect to organisms with well-defined depth preferences or requirements. For example, oysters are generally restricted to depths less than 8 meters (chiefly due to dissolved oxygen limitations), submerged aquatic vegetation is limited by light penetration, to about 2 - 3 meters, and so forth.

Seasonality and Temperature: Many organisms occupy a particular habitat only at certain seasons. This may reflect only response to temperature — a major seasonal variable — but also could result from seasonal differences in incident radiation, nutrients, life stage, or availability of food. Seasonal presence or absence of a predator or competition could also affect an organism's distribution (e.g. the reduction of Mnemiopsis leidyi in higher salinity areas in summer and fall by the predaceous ctenophore, Beroe ovata. Seasonality has been used to define and map habitats, wherever sufficient information was available.

Biotic Interactions: Organisms may themselves create a habitat, or modify it to such an extent that they affect the distribution of other species; e.g. the oyster bed (reef) and submerged aquatic vegetation beds, and their associated biota. In such cases, these species act as substrates, and are treated as such in our habitat classification system. As was discussed under "Seasonality" above, predation and competition can affect an organism's distribution, and must also be considered.

3. Bay Segmentation

The geographic limits of the study are the Chesapeake Bay and tributaries to the head of the tide, and seaward to a line connecting Cape Charles and Cape Henry at the point where the distance between the two capes is least. Fresh water study species are not mapped beyond the head of the tide and oceanic

study species are not mapped beyond the Capes. Thirteen Bay segments have been defined for use with the Chesapeake Bay Ecosystem Model (see Chapter VI of the final report), these were utilized for three duck species maps: Mallard, black duck and canvasback. The duck maps present mean densities of ducks within Bay segment boundaries as if they were evenly distributed.

4. Species Descriptions

Species descriptions follow for each of the 57 study species. Each account discusses aspects of range, salinity tolerance, tolerance to other factors, trophic importance, and the criteria used for mapping. Format is slightly different for different organism groups when certain factors require additional emphasis.

Map Appendix

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22.	*Evadne tergistina* - Cladoceran
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25.	*Heteromastus filiformis* - Polychaete Worm
26.	*Pectinaria gouldii* - Polychaete Worm
27.	*Scolecolepides virdis* - Polychaete Worm
28.	*Streblospio benedicti* - Polychaete Worm
29.	*Urosalpinx cinerea* - Oyster Drill
30.	*Crassostrea virginica* - Oyster
31.	*Macoma balthica* - Baltic Macoma
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41.	*Gammarus daiberi* - Amphipod
42.	*Leptocheirus plumulosus* - Amphipod
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44.	*Alosa sapidissima* - American Shad *Alosa pseudoharengus* - Alewife

Map Number	Title
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66.	Chesapeake Bay Sediments
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SYNOPSIS OF MAPPING CRITERIA
KEY TO TABLE B-1

DEFINITION OF TERMS:

MAP #: Refers to number of Map in Map Appendix.

SPECIES: Study Species or Association (may be more than one species on one map.

SEASON: Season mapped for species or life stage in question. This is usually the season of greatest abundance, sensitivity to low flow, reproduction, or trophic importance.

LIFE STAGE: Life stage(s) mapped.

SALINITY: Salinity ranges which delineate distribution, abundance, or seasonality. These represent typical or observed ranges from field data for the most part, not laboratory tolerances or anomalous occurrences.

DEPTH: Typical depth ranges for species' occurrence, based on field observations and season mapped. Some organisms may inhabit deeper water during cold months, or when dissolved oxygen is high at depth, although normally restricted to more shallow water.

SEDIMENT: Distribution and abundance in relation to sediment type are mapped for those species where this relationship has been demonstrated. Sediment types used are as follows:

Sand (S) = 75% sand
Muddy sand (M/S) = 50% sand, 25% silt and clay
Sandy mud (S/M) = 50% silt and clay, 25% sand
Mud (M) = 75% silt and clay

NUMBERS: These figures represent the typical abundance range of the species mapped, as taken from field data used in this project. Extreme maximum values encountered in this study are in parentheses.

N/A: Information not applicable to this species, or not available.

TABLE B-1. SYNOPSIS OF MAPPING CRITERIA

Phytoplankton

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY	DEPTH	SEDIMENT	NUMBERS
1	Winter/Spring phytoplankton associations:	Spring					
	Tidal Freshwater			0 - .5‰	Euphotic zone	n/a	n/a
	Oligohaline/low meschaline			3 - 10 ‰	Euphotic zone	n/a	n/a
	Meschaline			8 - 15 ‰	Euphotic zone	n/a	n/a
	Polyhaline			13 - Bay mouth	Euphotic zone	n/a	n/a
2	Summer/Fall phytoplankton associations:						
	Tidal Freshwater			0 - .5‰	Euphotic zone	n/a	n/a
	Oligohaline/low meschaline			3 - 13 ‰	Euphotic zone	n/a	n/a
	High meschaline/polyhaline			10‰ - Bay mouth	Euphotic zone	n/a	n/a
3	<u>Prorocentrum minimum</u> (dinoflagellate)	Winter		upstream to ca. 18 ‰	Usually below pycnocline	n/a	10 - 1000/ml *(to 10,000/ml)
		Summer		upstream to 5 ‰, downstream to ca. 18 ‰	Euphotic zone	n/a	500 - 10,000/ml * (to 1,000,000/ml)

*in area of accumulation

MAP #	Submerged Aquatic Vegetation SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
4	Submerged aquatic vegetation beds	general	all	n/a	generally less than 3 meters	non-hard substrates	n/a
	Note: These beds are mapped from aerial survey, and show only beds large enough to show up on these surveys. Zones of individual species distribution in maps 5 - 9 reflect verified occurrence both in surveyed beds and in beds too small to be included on Map 4.						
5	<u>Ceratophyllum demersum</u> (hornwort)	Spring	all	0 - 7‰	less than 3 meters	soft	n/a
6	<u>Potamogeton pectinatus</u> (sago pondweed)	Spring	all	0 - 12 ‰	less than 3 meters	all non-hard substrates	n/a
7	<u>Potamogeton perfoliatus</u> (redhead grass)	Spring	all	0 - 12‰	less than 3 meters	all non-hard substrates	n/a
8	<u>Zostera marina</u> and <u>Ruppia maritima</u> (eelgrass and widgeon grass)	<u>Z. marina</u>-(Spring) <u>R. maritima</u>-(Summer)	all	10 - Bay mouth 5 - Bay mouth	less than 3 meters	soft	n/a
9	<u>Zannichellia palustris</u> (horned pondweed)	Spring	all	0 - 15 ‰	less than 3 meters	soft	n/a

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
	Emergent Aquatic Vegetation						
10	Emergent Aquatic Vegetation	general	all	n/a	Emergent	n/a	n/a
	Note: This map represents known distribution of wetlands based on various surveys, and includes only marshes large enough to show up on aerial photography.						
11	Coastal Fresh Marsh Associations	n/a	all	0 - 5 ‰ *	Emergent	soft	n/a
12	Coastal Brackish Marsh	n/a	all	5 ‰ - Bay mouth *	Emergent	soft	n/a
13	Brackish Irregularly Flooded Marsh	n/a	all	10 ‰ - Bay mouth *	Emergent	soft	n/a
				* Period of inundation as important as salinity			
	Zooplankton						
14	*Mnemiopsis leidyi* (ctenophore)	Summer	adult	5 ‰ - Bay mouth	n/a	n/a	1 - 25/m3 (to 100/m3)
		Winter	adult	11 ‰ - Bay mouth	n/a	n/a	0 1 - 1.0/m3 (to 10/m3)
15	*Chrysaora quinquecirrha* (sea nettle)	Summer	medusa	5 ‰ - Bay mouth	n/a	n/a	0.5 - 5/m3
		Summer	polyp	7 ‰ - 20 ‰	0 - 10 m	hard substrates	10 - 50/m2

[illegible]	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
16	<u>Brachionus calcyiflorus</u> (rotifer)	Spring	Adult	0 - 0.5 ‰ (higher densities) 0.5 - 5 ‰ (lower densities)	n/a	n/a	500 - 10,000/m3 (to 50,000/m3)
17	<u>Acartia clausi</u> (copepod)	Spring	adult	5 - 10 ‰, 18 ‰ - Bay mouth (lower densities) 10 - 18 ‰ (higher densities)	n/a	n/a	500 - 10,000/m3 (to 50,000/m3)
18	<u>Acartia tonsa</u> (copepod)	Summer	adult	ca 0.1 - 1.0 ‰, 26 ‰ - Bay mouth (lower densities) 1.0 - 5 ‰, 20 - 26 ‰ (higher densities) 5 - 20 ‰ (high densities may be reduced by predation)	n/a	n/a	500 - 20,000/m3 (to 100,000/m3)
19	<u>Eurytemora affinis</u> (copepod)	Spring Summer	adult	0 -10 ‰ (higher densities) 10 - 12 ‰ (lower densities) 0 - 4 ‰	n/a	n/a	500 - 50,000/m3 (to 100,000/m3)

No. #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
20	<u>Scottolana canadensis</u> (copepod)	Summer	adult and copepodites	less than 1.0 ‰ and 5 - 10 ‰ (lower densities) 1 - 5 ‰ (higher densities)	Surface and bottom to 10 m	sediment preferences not known	50 - 1000/m3 (to 10,000m3)
21	<u>Bosmina longirostris</u> (cladoceran)	Summer	adult	0 - 0.5 ‰ (higher densities) 0.5 - 5 ‰ (lower densities)	n/a	n/a	500 - 20,000/m3 (to 100,000/m3)
22	<u>Evadne tergestina</u> (cladoceran)	Summer	adult	16 - 20 ‰ (lower densities) 20 - Bay mouth (higher densities)	n/a	n/a	1000 -10,000/m3 (to 100,000/m3)
23	<u>Podon polyphemoides</u> (cladoceran)	Spring	adult	3 - 8 ‰ and 22 ‰ - Bay mouth (lower densities) 8 - 22‰ (higher densities)	n/a	n/a	500 - 10,000/m3 (to 100,000/m3)

Benthic

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
24	Limnodrilus hoffmeisteri (oligochaete worm)	Spring	adult	0 - 0.5 ‰* (higher densities) 0 .5 - 1.0 ‰* (lower densities)	0 - 15 m	all	100 - 2,000/m2 (to 15,000/m2)
	Note: Areas of highest density were mapped from collection records, and may represent areas of organic enrichment. Also, species may occur in higher salinity under certain conditions (see Holland et al. 1980).						
25	Heteromastus filiformis (polychaete worm)	Summer	adult	2 - 5 ‰ 5 ‰ - Bay mouth	0 -10 m (lower densities) 0 - 6 m (higher densities) 6 - 10 m (lower densities)	all	10 - 500/m2 (to 2000/m2)
26	Pectinaria gouldii (polychaete worm)	Spring	adult	10 - 15 ‰ 15 ‰ - Bay mouth	0 - 15 m (lower densities) 0 - 10m (higher densities) 10 - 15 m (lower densities)	all	10 - 500/m2 (to 4000/m2)
27	Scolecolepides viridis (polychaete worm)	Spring	adult	0.5 - 1.0 and 10 - 15 ‰ (lower densities) 1.0 -5 ‰ 5 - 10 ‰	0 - 10 m 0 - 10 m	all types sand and M/S (higher dens.) S/M and mud (lower dens.)	50 - 2000/m2 (to 10,000/m2)

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
28	Streblospio benedicti (polychaete worm)	Summer	adults	5 ‰ - Bay mouth	1 - 20 m	sand (lower dens.) M/S, S/M, mud (higher dens.)	10 - 1000/m2 (to 5000/m2)
29	Urosalpinx cinerea (oyster drill) *Mapping of this species is based both on historic "drill lines" and recent collection information, as well as salinity.	general	adults	ca.12.5 ‰ to Bay mouth *	0 - 10 m	hard substrate	2 - 20/m2 (to 200/m2)
30	Crassostrea virginica (American oyster) *Mapping of this species is primarily based on extent and distribution of known oyster beds.	general	adults	ca. 7 ‰ to Bay mouth *	0 - 10 m	hard substrate	2 - 100/m2 (to 300/m2)
31	Macoma balthica (Baltic macoma)	Fall	adult	2.5 - 5 ‰ and 18 - 19 ‰ (lower densities) 5 - 18 ‰	0 - 15 m 0 - 10 m (higher densities) 10 - 15 m (lower densities)	all all	50 - 2000/m2 (to 5000/m2)
32	Mercenaria mercenaria (hard clam)	Summer	adult	12 - 12.5 ‰ (lower densities) 12.5 ‰ - Bay mouth	1 - 10 m 1 - 6 m 6 - 10 m	all shell, sand & M/S (higher densities) S/M & mud (lower dens.) shell, sand, M/S (lower densities)	2 - 15/m2 (to 25/m2)

No. #	SPECI	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
	<u>Mulina</u> <u>lateralis</u> (coot clam)	Fall/Winter	adult	10 - 15 ‰ (lower densities) 15 ‰- Bay mouth	0 - 15 m 0 -10 m (higher densities) 10 - 15 m (lower densities)	all	10 - 1000/m2 (to 4000/m2)
34	<u>Mya</u> <u>arenaria</u> (soft clam)	Spring	adult	3.5 - 5 ‰ (occasional) 5 - 8 ‰ (lower densities) 8 ‰- Bay mouth	0 - 6 m 0 - 6 m 0 - 6 m (higher densities) 6 - 10 m (lower densities)	all	10 - 500/m2 (to 1000/m2)
35	<u>Rangia</u> <u>cuneata</u> (brackish water clam)	Summer	adult	0.1 ‰(0) - 0.5 ‰ and 5 - 10 ‰ (lower densities) 0.5 - 5 ‰ (higher densities)	1 - 10 m	all	10 - 500/m2 (to 2000/m2)
36	<u>Ampelisca</u> <u>abdita</u> (amphipod)	Summer	adult	12 ‰- Bay mouth	3 - 6 m 6 - 15 m	M/S, S/M, mud (lower dens.) sand, (lower densities) M/S, S/M, mud (higher dens.)	50 - 2000/m2 (to 30,000/m2)

No. #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
	<u>Balanus improvisus</u> (acorn barnacle)	Summer	adult	2 - 5 ‰ (lower densities) 5 - 10 ‰ (higher densities) 10 - 20 ‰ (higher densities, but may be reduced by predation) 20 - 24 ‰ (occasional)	0 - 15 m	hard substrate	100 - 2000/m2 (to 5000/m2)
38	<u>Callinectes sapidus</u> (blue crab)	Summer	adults and larger juveniles	0 - 15 ‰ (predominantly male) *	0 - 6 m (higher densities) greater than 6 m (lower densities)	all types	0.05 - 5/m2 (rough estimate from trawl data)
				10 ‰-Bay mouth (predominately females) *	0 - 6 m (higher densities) greater than 6 m (lower densities)		
			spawning areas	25 ‰ to shelf	surface, primarily near shore	n/a	n/a
	* This is relative, as some males are found in the lower Bay, and some females in the upper Bay.						
39	<u>Callinectes sapidus</u> (blue crab)	Winter	adults and larger juveniles	generally above 5 ‰ to about 20 ‰ (predominately male) *	13 - 20 m (lower densities) greater than 20 m (higher densities)	mostly S/M, mud	n/a
				generally above 20 ‰ (predominately female)*	10 - 15 m (lower densities) greater than 15 m (higher densities)	mostly M/S, S/M, mud, and some fine sand	
	* See note above						

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
	<u>Cyathura</u> <u>polita</u> (isopod)	Summer	adults	0.5 - 1.0 ‰ and 10 - 12 ‰ (occasional)	0 - 6 m	all types	50 - 500/m2 (to 1000/m2)
				1 - 7 ‰	0 - 6 m	sand, [illegible]S, and S/M (higher dens.) mud (lower dens.)	
				7 - 10 ‰ (lower densities)	0 - 6 m	all types	
41	<u>Gammarus</u> <u>daiberi</u> (amphipod)	Summer	adult	0.5 - 1 ‰ and 5 - 7 ‰ (lower densities)	0 - 6 m (may also occur pelagically)	all types (where shelter exists)	50 - 500/m2 (to 4000/m2)
				1 - 5 ‰ (higher densities)			
42	<u>Leptocheirus</u> <u>plumulosus</u> (amphipod)	Spring	adult	0.5 - 1 ‰ and 10 - 15 ‰ (lower densities)	0 -15 m	all	50 - 4000/m2 (to 10,000/m2)
				1 - 10 ‰	0 - 10 m (higher densities) 10 - 15 m (lower densities)		
43	<u>Palaemonetes</u> <u>pugio</u> (grass shrimp)	Summer	adult and older juveniles	1 - 5 ‰ (lower densities)	0 - 3 m	all, where suitable habitat exists	5 - 50/m2 (to 200/m2)
				5 - 15 ‰ (higher densities)			
				15 - 20 ‰ (found with <u>P.</u> <u>vulgaris</u>)			

Fish

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
44	Alosa sapidissima (American shad)	Spring	eggs and larvae	surface head of tide - 3 ‰	greater than 3 m	n/a	n/a
	A. pseudoharengus (alewife)	Spring	eggs and larvae	surface head of tide - 3 ‰	less than 3 m		
	A.s. and A.p.	Summer/Fall	juveniles	0 - 5‰	shore to shore		
	A.p.	Summer/Fall	adult	(not mapped)			
45	Brevoortia tyrannus (menhaden)	Summer	larvae and juveniles	surface 0 - 5 ‰	1 meter to depth	n/a	n/a
			adult	5 - 18 ‰ (higher concentrations)	1 meter to depth		
				5 - 34 ‰ (general distribution)	1 meter to depth		
46	Anchoa mitchelli (Bay anchovy)	Summer	eggs	5 - 15 ‰	shore to shore	n/a	n/a
			larvae	3 - 7 ‰	shore to shore	n/a	n/a
			adults	0 - 34 ‰	shore to shore	n/a	n/a
47	Micropogonias undulatus (Atlantic croaker) Leiostomus xanthurus (spot)	Fall	larvae & juvenile (both species)	0 - 7 ‰	greater than 1 m	n/a	n/a

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
cont. 47-	_M. undulatus_	Summer	adult	10 - 34 ‰	greater than 3 m	n/a	n/a
	L. xanthurus	Summer	adult	8 - 34 ‰	greater than 1 m	n/a	n/a
48	_Menidia menidia_ (Atlantic silverside)	Summer	adult	3 - 34 ‰	shallow, less than 1 meter, main Bay less than 7 m, rivers	n/a	n/a
49	_Morone americana_ (white perch)	Spring	egg & larvae	tidal fresh	shore to shore	n/a	n/a
		Summer	juveniles	0 - 5 ‰	0 - 3 meters	n/a	n/a
		Summer	adults	0 - 34 ‰	shore to shore	n/a	n/a
50	_Morone saxatilis_ (striped bass)	Spring	egg & larvae	tidal fresh	shore to shore	n/a	n/a
		Summer	adult	greater than 5 ‰	shore to shore	n/a	n/a
		Winter	adult	greater than 5 ‰	greater than 6 m	n/a	n/a
51	_Perca flavescens_ (yellow perch)	Fall (in lieu of winter salinities)	egg & larvae	tidal fresh	shore to shore	n/a	n/a
		Summer	juvenile & adult	less than 12 ‰	shore to shore	n/a	n/a

Birds

MAP #	SPECIES	SEASON	LIFE STAGE	SALINITY (‰)	DEPTH	SEDIMENT	NUMBERS
52	<u>Anas platyrhynchos</u> (mallard)	Winter	adult	n/a	concentrated in shallow areas	n/a	*100 - 1000/100km2
53	<u>Anas rubripes</u> (black duck)	Winter	adult	n/a	concentrated in shallow areas	n/a	*100 - 1000/100km2
54	<u>Aythya valisineria</u> (canvasback)	Winter	adult	n/a	various	n/a	*100 - 1000/100km2

*Represents 5 year means.

SPECIES DESCRIPTIONS

Winter/Spring Phytoplankton Associations (Map #1)

Description:

Phytoplankton species which occur from late November through late April constitute the Chesapeake Bay winter/spring associations floras. These associations include only the larger, "net" phytoplankton, because of the paucity of distribution and seasonality data on the small nannoplankton. However, the latter groups account for approximately 80% of the primary productivity in Chesapeake Bay.

Range and Composition:

Species which occur in Chesapeake Bay during colder months include both ubiquitous, year round forms, and boreal/cold temperatre species. Representation species for each of the four associations are:

Tidal Freshwater:

Melosiragranulata - diatom
Cyclotella meneghiniana - diatom
Skeletonema potamos - diatom
Asterionella formosa - diatom
Coscinodiscus curvatulus - diatom
Pandorina morum - chlorophyte

Oligohaline/Low Mesohaline:

Katodinium rotundatum - dinoflagellate
Skeletonema costatum - diatom
S. potamus - diatom
Asterionella formosa - diatom
Ankistrodesmus falcatus - chlorophyte

Mesohaline:

Katodinum rotundatum - dinoflagellate
Skeletonema costatum - diatom
Ceratulina bergonii - diatom
Asterionella japonica - diatom
Chaetoceros sociales - diatom
Calicomonas ovalis - chrysophyte

Polyhaline:

Peridinium tri quetum - dinoflagellate
Prorocentrum micans - dinoflagellate
P. minimum - dinoflagellate
Nitzschia pungens - diatom
Asterionella japonica - diatom
Skeletonema costatum - diatom
Chaetoceros decipiens - diatom
C. socialis - diatom
Rhizosolenia alata - diatom
Ebria tripartita - silicoflagellate

From area to area, and year to year, the exact composition of the various associations changes as different species dominate. The above are typical assemblages for the winter/spring Chesapeake Bay.

Salinity Relationships:

There is considerable overlap in the distributions of the various

assemblages in regard to salinity, and the overall effect is a continuous gradation from one association to another, with few abrupt changes. The tidal freshwater oligohaline transition is probably the most marked.

General salinity ranges for the four associations are:

Tidal Freshwater	0-5 ‰
Oligohaline/Low Mesohaline	3-10 ‰
Mesohaline	8-15 ‰
Polyhaline	13 ‰-Bay mouth

Other Sensitivities:

Phytoplankton are limited by light penetration to the upper layers of the estuary. Depth of the euphotic zone varies from area to area within the Bay. As a generality it is shallowest at the fresh water estuarine tansition zone, and deepest in the lower Bay. In winter, the euphotic zone is deeper than in summer months.

Temperature affects the Bay phytoplankton at both the community and the species level: first, by determining what species are present, and second, by affecting their rate of nutrient uptake, photosynthesis, and cell division. The winter/spring flora generally occurs in Chesapeake Bay when temperatures are less than 15°C.

Nutrient input from runoff is reduced during winter, but elimination of thermal stratification and overturn by wind action serves to mix nutrients into the euphotic zone. Increasing insolations rising temperatures, and initiation of spring runoff triggers increased phytoplankton growth in spring. The spring phytoplankton bloom is most pronounced in the polyhaline areas of Chesapeake Bay (Heinle et al. 1980), and is dominated by diatom species.

Low flow conditions can be expected to shift the relative distribution of the four associations. In addition, changes in runoff could alter nutrient input, estuarine flushing rates (important to maintainence of phytoplankton within the estuary), turbidity, and stratification.

Trophic Importance:

Phytoplankton are the major primary producers for most estuarine food webs. Nannoplankton (species less than 10μ) dominate primary productivity in Chesapeake Bay (McCarthy *et al*. 1974, Van Valkenburg and Flemer 1974). Most copepods can utilize algae down to 8μ or so in size, and microzooplankters such as rotifers and tintinnids can ingest even smaller forms (Richman *et al*. 1977). However, larger species of phytoplankton can be used by zooplankton and juveniles of planktivorous fish. Benthic suspension feeders also graze phytoplankton heavily. Oysters feed upon smaller species, primarily nannoplankton (Haven and Morales-Alamo 1970). Not all species of phytoplankton are equally good as food, and some (such as toxic dinoflagellates) are detrimental. "Nuisance blooms" of algae are primarily a summer phenomena in Chesapeake Bay, but blooms of cold water dinoflagellates such as *Katodinium rotundatum* have also been observed. Eutrophication of many Bay tributaries has contributed to these phenomena.

Sources:

Dahlberg *et al*. 1973
Ecological Analysts 1974
Haven and Morales-Alamo 1970
Heinle *et al*. 1970
Johns Hopkins U. 1972
Lear and Smith 1976
Mackiernan 1968 unpubl.
Marshall 1966, 1967
McCarthy *et al*. 1974
Morse 1947
Mountford 1977
Mulford 1972
Patten *et al*. 1963
Richman *et al*. 1977
Seliger *et al*. 1975
Van Valkenburg and Flemer 1974
Van Valkenburg *et al*. 1978

Summer/Fall Phytoplankton Associations (Map #2)

Description:

Phytoplankton species which occur from early May through November constitute the Chesapeake Bay summer/fall associations or floras.

Composition:

Species which occur in Chesapeake Bay during warmer months for each of the four associations are:

Tidal Freshwater:

Anacystis cyanea	blue-green algae
Microceptus aeruginosa	(most important in
Anabaena flos-aquae	eutrophied areas)
Skeletonema potamos	- diatom
Melosira granulata	- diatom
Cyclotella meneghiniana	- diatom
Scenedesmus	- chlorophyte
Pediastrum	- chlorophyte
Euglena	- euglenoid

Oligohaline/Low Mesohaline:

Gymnodinium nelsoni	- dinoflagellate
G. splendens	- dinoflagellate
Prorocentrum minimum (mariaeleborual)	- dinoflagellate

Oligohaline/Low Mesohaline (cont.)

Skeletonema costatum	- diatom
Diatoma hemale	- diatom
Nitzschia closterium	- diatom
Eutreptiella marina	- euglenoid

High Mesohaline/Polyhaline Associations

Gymnodinium splendens	- dinoflagellate
Cochlodinium heterolobatum	- dinoflagellate
Ceratium furca	- dinoflagellate
Skeletonema costatum	- diatom
Ditylum brightwelli	- diatom
Chaetoceros affinis	- diatom
C. subtilis	- diatom
C. compressus	- diatom
Thallassionema nitzochoides	- diatom

As with the winter/spring associations, the exact floral composition changes from year to year. The above are typical species for summer and fall.

Salinity Relationships:

The remarks for winter/spring generally apply here, although the salinity ranges are somewhat different.

Tidal Fresh Water	0 - 5 ‰
Oligohaline/Low Mesohaline	3 -13 ‰
High Mesohaline/ Polyhaline	10‰ - Bay mouth

Other Sensitivities:

The general remarks for winter/spring apply here. Increasing turbidity in warmer months (due to runoff as well as increased phytoplankton biomass) decreases the depth of the euphotic zone. Warmer temperatures and greater insolation contributes to strat-

ification, reducing nutrient input from bottom waters. The major source of nutrients to phytoplankton in warm months is from autochthonous regeneration within the euphotic zone. The situation of low nutrient availability, organic nutrient sources, and shallow euphotic zone tends to favor species with rapid uptake rates, small cell size, many flagellated. The summer/fall associations occur in Chespeake Bay generally when temperature exceeds 15°C.

Trophic Importance:

General remarks for winter/spring apply here. Summer months are the primary period of phytoplankton blooms, "red water", and noxious blue-green water bloom. There is evidence that the frequency of such blooms is increasing in some Bay areas with increasing eutrophication (Heinle *et al*. 1980); however, improvement in water treatment has caused reduction in frequency of summer blue-green blooms in many rivers.

Sources:

Dahlberg *et al*. 1973
Ecological Analysts 1974
Heinle *et al*. 1980
Johns Hopkins U. 1972
Lear and Smity 1976
Mackiernan 1968 Unpubl.
Marshall 1966, 1967
Morse 1947
Mountford 1972
Nulford 1972
Patten *et al*. 1963
Seliger *et al*. 1975
Van Valkenburg *et al*. 1978

Prorocentrum minimum (P. mariaelibourae) - Dinoflagellate (Map #3)

Description:

Prorocentrum minimum (Also referred to as P. Mariaelebourae, based on work by M. Faust (1974)) is a small dinoflagellate of the family Prorocentraceae. It is oval in shape, flattened, about 15 - 20 μ in length and somewhat less in width, with two anterior flagellae. Color is a golden or reddish brown.

Range:

P. mimimum occurs in the east coast of North America and in European Atlantic waters, generally in estuarine or neritic waters. In Chesapeake Bay it has virtually cosmopolitan, but seasonal distribution. Densities are normally less than 1000 cells/ml, but during blooms of this species, over 10,000 cells/ml have been recorded. In addition, in areas of accumulation (due to circulation patterns coupled with positive phototaxis of the dinoflagellate) densities may reach 1,000,000 cells/ml.

The seasonal distribution of P. minimum is complex, and closely linked to estuarine circulation patterns. A complete and detailed discussion is included in Tyler and Seliger (1978), but a brief synopsis follows: In late winter, Prorocentrum populations are entrained into northward flowing saline water below the strong pycnocline. It is transported upestuary, reaching the vicinity of the Bay Bridge by late spring. The

decreasing depth of the upper Bay causes the pycnocline to rise, and mixes the dinoflagellate and nutrient rich deep water into the euphotic zone. Rapid growth and physical accumulation causes the formation of extensive "red water" patches. *Prorocentrum* carried down-estuary in surface waters sequentially inoculates tributary estuaries; these populations exchange slowly with the Bay mainstem. By mid-winter, the dinoflagellate reaches the Bay mouth, where the cycle repeats (Refer to Figure III-8, Volume 1). Timing of the entrainment and arrival in the bloom area is highly correlated with metereological events, runoff, and circulation velocities (Seliger *et al*. 1979, Tyler and Seliger 1979).

Salinity Relationships:

The salinity tolerance of this species is closely tied to temperature (Mackiernan unpubl., Tyler and Seliger 1980). In general, at temperatures below 5°C, little or no cell division takes place if salinities are below 15‰. As temperatures increase, division rates also increase: at 10°C and 5‰, rates are approximately one half the maximum (Mackiernan, unpubl., Tyler and Seliger 1980). Near-maximum growth rates occur over a wide range of salinities (5-30‰) at summer temperatures (approximately 22-25°C).

This has implication for the distribution and survival of *P. minimum* in the Bay. Physiologically, the species' growth response enables it to survive winter in the lower Bay region. However, if the upestuary transport is too early, and the dinoflagellate arrives in the upper Bay while ambient water temperatures are still low, the summer bloom may never develop. Timing of transport is related to streamflow, particularly from southern tributaries (entrainment) and the Susquehanna (transport). This is more fully discussed in Seliger *et al*. (1979) and Tyler and Seliger (1980).

Other Sensitivities:

The relationship of *Prorocentrum* to temperature is discussed above.

In general, temperatures from 20-30°C support maximum growth rates at or near one doubling day^{-1} (Mackiernan unpubl.).

Prorocentrum minimum is able to maintain the appropriate division rate for the temperature over a wide range of light levels from 0.2 to 0.02 langleys min^{-1} (Mackiernan unpubl.). Tyler and Seliger (1980) report that the species is able to photosynthesize at very low light levels typical of the pycnocline region in winter. This adaption to low light levels is important in allowing survival of the cells during upestuary transport.

Occasionally, upstream transport of the dinoflagellate is delayed, and mortality occurs because of anoxia developing below the pycnocline (Seliger et al. 1979).

Potential Habitat:

In summer, potential habitat are areas above 5‰ salinity, in the euphotic zone. There is no real physiological downstream boundary, but in the Bay mainstem, populations generally occur only through the mesohaline zone. Populations also occur in warm months at the mouths of tributary rivers. The flushing rate of the lower Bay is such that Prorocentrum populations rarely build up in the surface waters of the mainstem. The species may occur along the western shore in summer, originating from populations in the lower rivers (Tyler, personal communication).

In winter, populations occur downstream of 15-18% , usually below the pycnocline. Both winter and summer distribution varies greatly with hydrological conditions.

Trophic Importance:

As a dominant phytoplankton species, particularly in summer, P. minimum contributes to th productivity of the estuary. In nutrient-poor water, it exhibits a nocturnal migration to the

higher nutrient pycnocline region. This not only conveys a selective advantage upon *P. minimum*, but it also enhances transport of nutrients into the euphotic zone, as cells die and are remineralized.

P. minimum is fed upon by a wide variety of zooplankton, including copepods, cladocerans, and rotifers, as well as larvae of numerous invertebrates. In addition, it has been observed that juvenile menhaden being transported upestuary in deep layers, concurrent with the *P. mimimum* transport, were apparently feeding heavily on the dinoflagellate (Tyler pers. comm.).

Selection Factors:

- Dependence of species' occurrence, in much of range, upon streamflow, estuarine circulation, salinity, and flushing rates of subestuaries, as factors potentially impacted by low flow.
- Importance as a major bloom organism in summer in Chesapeake Bay.
- Role as indicator or "model" for numerous species which utilize estuarine circulation for part of their lifecycle.

Sources:

Allison 1980
Faust 1974
Jordan *et al*. 1975
Lippson *et al*. 1979
Mackiernan unpubl. 1968
Mountford 1977
Mulford 1972
Seliger *et al*. 1975, 1979
Stophan 1974
Tyler and Seliger 1978, 1979, 1980
Zubkoff and Warinner 1975

Ceratophyllum demersum - coontail (Map #5)

Description:

Ceratophyllum demersum is a submerged angiosperm. It is considered to be primarily a freshwater species although it apparently can tolerate salinities in the Oligohaline range (Bourn 1932).

Range:

In Virginia, Orth et al. (1979) found Ceratophyllum in 35% of the vegetated samples taken. While in Maryland, the 1978 and 1979 MBHRL survey found little or no Ceratophyllum. However, Ceratophyllum was found in pervious MBHRL surveys on the Susquehanna flats, Mogothy, Severn and Chester Rivers. Frequency of occurrence was less than 1 %.

Salinity Relationships and Potential Habitat:

Although Ceratophyllum demersum is generally restricted to tidal freshwater areas (0 - 0.5‰), the species does occur in oligohaline environments as well. Potential habitat for the species has been defined as shallow (<3 meters) non-turbid areas with salinities less than 7‰ (Bourn 1932).

Trophic Importance:

The importance of Ceratophyllum, as a food for waterfowl may be limited in the Chesapeake Bay. Rawls (in press) reported a frequency of occurrence of .42% in the 1,179 waterfowl stomachs

he examined. *Ceratophyllum* comprised .33% of the total volume of food in these stomachs.

In Virginia, *Ceratophyllum* was found to be an important member of a submerged aquatic vegetation community consisting of the following species (Orth *et al.* 1979):

Najas minor	*Potamogeton foliosus*
Najas guadalupensis	*Najas flexilis*
Elodea canatensis	*Potamogeton filiformis*
Nitella sp.	*Potamogeton nodosus*
Callitriche verna	*Elodea nuttalli*

Sources:

Bourn 1932

Orth *et al.* 1979

Rawls (in press)

Potamogeton pectinatus - Sago Pondweed (Map #6)

Description:

Potamogeton pectinatus is a submerged aquatic angiosperm. It grows in shallow waters (<3 meters) and generally requires fresh or low salinity waters.

Range:

Potamogeton pectinatus is found throughout the Chesapeake Bay. In Maryland, this species was found in approximately 15% of the vegetated samples during the 1978 MBHRL survey. In Virginia, Orth et al. (1979) found P. pectinatus in 6% of the vegetated samples. It commonly occurred with the following species:

Potamogeton crispus	Callitriche verna
Potamogeton perfoliatus	Chara
Vallisneria americana	Myriophyllum spicatum

Salinity Relationships and Potential Habitats:

Although the species in this association were commonly found in waters with a salinity equal to or less than 15 parts per thousand, P. pectinatus apparently does not do well in salinities greater than 12-13 parts per thousand (Jetter 1965). Potential habitat for this species is defined as areas less than 3 m depth, soft substrate, salinities less than 12‰.

In Maryland, past MBHRL surveys found *P. pectinatus* in a survey of areas (Steverson and Confer 1978). They were:

Easter Bay	Patapsco River
Choptank River	Big and Little Annamessex Rivers
Little Choptank River	Magothy River
James Island and Horga River	Severn River
Bloodsworth Island	Chester River
Manokin River	Smith Island (Maryland)

Trophic Importance:

P. pectinatus is an important waterfowl food. Rawls (in press) found this species in 2.3% of the 1,179 waterfowl stomachs he examined, while Stewart (1962) found it often in waterfowl stomachs.

Sources:

Jeeter 1965
Stevenson and Confer 1978
Rawls (in press)
Stewart (1962)

Potamogeton perfoliatus - Red head grass (Map #7)

Description:

Potamogeton perfoliatus is a submerged aquatic macrophytic angiosperm. It is slightly more salt tolerant than Potemogeton pectinatus and is frequently associated with brackish waters.

Range:

Potamogeton perfoliatus was the second most abundant species found in the 1978 Maryland MBHRL survey, occurring in approximately 27% of the vegetated samples. Only Ruppia maritima was more abundant. In Virginia waters, Orth et al. (1979) found P. perfoliatus in 6% of their vegetated samples. It commonly occurred with the following species:

Potamogeton crispus
Potamogeton pectinatus
Vallisneria americana
Zannichellia palustris
Callitriche verna
Chara
Myriophyllum spicatum

Salinity Relationships:

P. perfoliatus is found in freshwater and in estuaries with up to about 12 parts per thousand salt (Stevenson and Confer 1978). Potential habitat for this species is defined as areas less than 3 m deep, soft substrates, over 10‰ salinity.

The distribution of *P. perfoliatus* in Maryland as found in past MBHRL vegetation surveys is listed below:

Eastern Bay
Choptank River
Patapsco River
Magothy River
Severn River
Chester River

Trophic Importance:

P. perfoliatus is an important source of food to water fowl. Rawls (in press) found this species in 29.6% of the 1,179 water-fowl stomachs he examined. This frequency of occurrence was second only to *Ruppia maritima*. Ten percent of the total volume of vegetation found in these stomachs was the remains of *P. perfoliatus*.

Sources:

Orth *et al*. 1979
Stevenson and Confer 1978

Zostera marina - eelgrass (Map #8)

Description:

Zostera marina is a grasslike submerged aquatic angiosperm. Where salinity conditions are correct for its growth, it is often locally abundant growing in extensive submerged beds in waters 1-6 meters deep.

Range:

Zostera marina is found primarily in the Virginia portion of the Chesapeake Bay, in salinities above than 8-10 parts per thousand. Zostera above ground biomass is present throughout the year, but with reduced growth during the winter months.

In Maryland waters the 1978 MBHRL survey found Zostera in 5% of the vegetated samples. In Virginia, Orth et al. found more than 84,000 hectares of submerged aquatic vegetation beds, with Zostera and Zostera/Ruppia being the dominant vegetation. The only species found in abundance with Zostera is Ruppia maritima.

Salinity Relationships and Potential Habitat:

Zostera is a species with salinity tolerances usually limited to above 18‰. The species is found from mesohaline to marine salinities, primarily in the lower bay.

Trophic Importance:

In the Chesapeake Bay the importance of *Zostera* as a direct food source is overshadowed by other factors. *Zostera* is important as a stabilizer of sediments, being able to trap and bind sediment particles. *Zostera* is probably also important as a nutrient pump, whereby nitrogen and phosphorus are released from the sediments. Probably the most important role of *Zostera* in the Chesapeake Bay is as a habitat for other species. A great number of organisms live on the leaves of *Zostera*, as well as in and on the substrate found in the beds. Many organisms use the beds for feeding and protection.

In terms of *Zostera* as a direct source of food for waterfowl, Rawls (in press) found this species in .34% of the 1,179 waterfowl stomachs he examined. Stewart (1962) reported considerably higher values for a number of waterfowl species. However, these results depend upon where in the Bay the birds were collected since birds feeding in the upper portion would not have access to *Zostera*.

Sources:

Rawls (in press)
Stewart 1962

Ruppia maritima - widgeon grass (Map #8)

Description:

Ruppia maritima is a submerged aquatic macrophyte, often found associated with Zostera marina. It grows in brackish and marine waters of Chesapeake Bay.

Range:

Ruppia is found throughout the Chesapeake Bay in salinities ranging from the mesohaline range to the salinity of seawater. It occurs in association with Zostera marina in the shallower portions of that species range and alone or with other submerged aquatic vegetation in areas of lesser salinities.

Ruppia is relatively abundant in the Chesapeake Bay. The MBHRL submerged aquatic survey found Ruppia in approximately 70% of their vegetated samples. Orth, Moore and Gordon (1979) found Ruppia in approximately 12% of their vegetated samples in Virginia waters.

In Maryland, past MBHRL surveys have found Ruppia in the following areas:

Eastern Bay	Little Choptank
Choptank River	James Island & Honga River

Honga River
Bloodworth Island
Fishing Bay
Manokin River
Big & Little Annamessex Rivers
Pocomoke Sound (Maryland)
Magothy River
Severn River
Patuxent River
Back, Middle & Gunpowder Rivers
Chester River
Love and Kent Points
Smith Island (Maryland)

Salinity Relationships and Potential Habitat:

Ruppia maritima is found in salinities greater than 5 ppt. It is found in shallow water areas from this salinity to salinities of full seawater.

As *Ruppia* reaches its greatest growth in warm months, it is mapped against summer salinities. Potential habitat is defined as areas less than 2 m deep, over 5 salinity (Anderson and Macomber, unpublished).

Trophic Importance:

Ruppia is an important waterfowl food in the Chesapeake Bay. Rawls (in press) found this species in approximately 30% of the 1,179 waterfowl stomachs he examined. *Ruppia* comprised about 11% of the total volume of all food found in these stomachs. Seeds, leaves, stems and rhizomes are eaten by waterfowl. *Ruppia* is also used as a habitat for many aquatic organisms.

In Virginia, Orth *et al*. (1979) found *Ruppia* to be associated with *Zostera marina* in large beds, although little *Ruppia* was found in areas without *Zostera*.

Sources:

Orth *et al*. 1979

Zannichellia palustris - Horned pondweed (Map #9)

Description:

Zannichellia palustris is a submerged aquatic angiosperm. It is usually found in non-stagnant fresh or brackist waters.

Range:

Zannichellia palustris was the most frequent SAV species found in vegetated samples in Virginia waters of the Chesapeake Bay (Orth et al. 1979). In Maryland Zannichellia was found in 17% of the vegetated samples in the 1978 MBHRL survey. In the past, Zannichellia frequency and distribution has been found to be erratic (Stevenson and Confer 1978). Zannichellia is a species which is able to colonize habitats as they become available. It also declines relatively early in the summer, a factor which perhaps accounts for its erratic distribution when mapped later in the summer. Past Maryland MBHRL surveys have found Zannichellia in Eastern Bay, and the Choptank, Little Choptank, Severn, and Chester Rivers.

In Virginia, Zannichellia has been found in association with the following species (Orth et al. 1978):

Potamogeton crispus
Potamogeton perfoliatus
Potamogeton pectinatus
Vallisneria americana
Callitriche verna
Chara
Myriophyllum spicatum

Salinity Relationships and Potential Habitat:

This association is commonly found in waters with a salinity equal to or less than 15 parts per thousand. Although commonly found in association with the above species, *Zannichellia* also occurs in monospecific beds. Potential habitat for this species is defined as areas less than 3 m deep, under 15‰ salinity.

Trophic Importance:

Zannichellia is probably not as important as some other species of submerged aquatic vegetation or food for waterfowl. Rawls (in press) found remains of *Zannichellia* in only .34% of the 1,179 stomachs he examined. However, *Zannichellia* is likely to be important as a habitat to aquatic organisms.

Sources:

Orth *et al*. 1979

Sevenson and Confer 1978

Coastal Fresh Marsh Association - (Map #11).

Description:

The species that comprise this category of marsh are for the most part restricted to fresh water areas. These marshes typically have a very high diversity of species, and can be dominated by a number of different forms. However, it is probably more common for fresh water marshes to have a mixture of abundant species. This marsh category was formed from the following Maryland and Virginia marsh categories.

A Maryland
- Type 12, coastal shallow fresh marsh
- Type 13, coastal deep fresh marsh
- Type 14, coastal cpen fresh marsh

B Virginia
- Type 6, Typha community (T. latifolia and T. angustifolia)
- Type 7, Peltandra virginica/Pontederia cordata community
- Type 8, Phagmites australis community
- Type 9, Nuphar luteum community
- Type 11, freshwater mixed community

Although many emergent plant species are found in coastal fresh marshes, the following species are very common:

Acorus calamus
Hibiscus palustris
Leersia spp.
Nuphar leiteum
Peltandra virginica
Phracmites australis
Polygonum spp.
Pontederia cordata
Sagittaria latifolia
Typha angustifolia
Typha latifolia
Zizania aquatica

Range and Salinity Relationships:

Period of inundation is as important as salinity in determining species present (Boone 1977). Changes in tidal amplitude or current structure due to low flow could affect the distribution of these marshes, as could salinity changes *per se*. Most of the above species are found in fresh water and oligohaline areas, although some (eg. *Hibiscus*) penetrate to mesohaline salinities. In general, the fresh water marsh associations are limited to areas upstream of 3 - 5 ‰ salinity. However, localized fresh water inputs allow occurrence of this marsh type in other parts of the Bay, or occasionally within brackish or salt marsh stands.

Trophic Importance:

The leaves, stalks, rhizomes, and seeds of the vegetation in these marshes are important to waterfowl and animals such as muskrats. Freshwater marshes also serve as nursery grounds for fish. The marshes serve as sources of detritus to the vast coastal detrital food web, and nutrients are released upon decomposition.

Selection Factors:

- Importance as direct source of food for birds and other wildlife
- Importance of this marsh type to detrital supply in fresh and oligohaline areas, and thus to fish nursery grounds
- Role in nutrient recycling
- Habitat for larval and juvenile fish, crabs, and other wildlife
- Potential vulnerability to effects of low flow

Coastal Brackish Marsh - (Map #12).

Description:

Most of the species found in coastal brackish marshes are restricted to brackish areas by competition, and not because of intolerance to fresh water. Plant species diversity in brackish marshes is usually lower than in fresh water marshes, with species often occurring in large monospecific stands. This marsh category is formed from the following Maryland and Virginia marsh categories:

A Maryland

- Type 16 coastal salt meadow
- Type 18 coastal regularly flooded salt marsh

B Virginia

- Type 1 *Spartina alterniflora* community
- Type 2 *Spartina patens/Distichlis spicata* community
- Type 4 *Baccharis halimifolia/Iva frutescens* community
- Type 5 *Spartina cynosuroides* community
- *Type 6 *Typha* (*Angustifolia* or *T. latifolia*) community
- Type 10 *Salicornia* sp. community
- Type 12 Brackish water mixed community

Emergent plant species which are common in coastal brackish marshes include the following:

Baccharis halimifolia	*Salicornia* spp.
Distichlis spicata	*Scirpus* spp.
Iva frutescens	*Spartina alterniflora*
Limonium carolinianum	*Typha* spp.

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*Virginia marshes dominated by these species were classified as coastal brackish depending upon the associated species present.

Range and Salinity Relationships:

Again, duration and extent of tidal inundation is a primary factor controlling distribution of species within the marsh. Most are restricted to more saline environments by competition, and not by effects of reduced salintiy. Many of these species are found from low mesohaline to polyhaline regions. Again, changes in tidal amplitude, drainage patterns, or salinity due to low flow could affect the species composition and abundance of this marsh type. In general, these marsh types occur above 5‰ salinity in both Bay mainstem and tributaries.

Trophic Importance:

The emergent vegetation in brackish marshes is generally of lesser direct value as food for waterfowl than is the emergent vegetation of freshwater marshes. Coastal marshes contribute much detritus to the nutrient cycle and food web of the estuary, however. They are also extremely important as a permanent or temporary habitat for waterfowl, other birds, animals such as muskrats, and fish.

Selection Factors:

- Importance to nutrient cycling and detritus based food webs
- Importance as habitat for wildlife, as well as fish and crabs
- Potential vulnerability to changes produced by low flow conditions

Brackish Irregularly Flooded Marsh - (Map #13).

Description:
These brackish marshes, dominated by *Juncus roemerianus*, are very prevalent in both Maryland and Virginia. Plant species diversity is usually extremely low in this type of marsh because *Juncus* typically occurs in large, monospecific stands. Other species, such as *Spartina alterniflora*, *S. patens*, and *Distichlis spicata* may be present near the margins of the *Juncus* marsh.

This marsh category was formed from the following Maryland and Virginia marsh categories:

A Maryland
- Type 17 Irregularly flooded salt marsh

B Virginia
- Type 3 *Juncus roemerianus* community

Range and Salinity Relationships:
As with the preceding marsh types, extent and duration of inundation affects the occurrence of this marsh type; *Juncus* stands occur in portions of the marsh subject to less tidal inundation than do the *Spartina alterniflora* stands. The species found in this marsh type tolerate salinities from low mesohaline (or even oligohaline) to euhaline, and are apparently confined to more saline areas by competition. Again, tidal or drainage fluctuations, as well as salinity changes, due to low flow could affect the distribution and abundance of this marsh type. As with the preceding marsh type, brackish irregularly flooded marsh occurs generally in areas above 5‰ salinity.

Trophic Importance:

Juncus is little used as a direct food source by animals, and ia used relatively less as habitat due to its density and sharp tipped sturcture. However, its productivity and abundance make it important in the detrital food webs and in nutrient cycling. Its dense rhizome structure also makes Juncus effective in preventing erosion, especially on sandy substrates.

Selection Factors:

- Importance to detrital food webs and nutrient cycles in higher salinity areas
- Importance to erosion control
- Potential vulnerability to low flow effects

Mnemiopsis leidyi - Ctenophore (Sea Walnut) (Map#14).

Description:

Mnemiopsis leidyi is a lobate ctenophore of the family Mnemiidae. It is a transparent, gelatinous animal, roughly pear-shaped, with four oral lobes. Adults have no tentacles. The organism swims by means of its 8 rows of comb-like plates. *Mnemiopsis* uses its body lobes and comb plates to capture the zooplankton on which it primarily feeds. Maximum size is approximately 75 mm. *Mnemiopsis* exhibits bioluminiscence, flashing if touched or disturbed at night.

Range:

M. leidyi is found in estuarine and near-shore areas in cool and warm temperate waters of the Atlantic. In tropical and subtropical areas it is replaced by the slightly larger *M. mcradyi*. In Chesapeake Bay, *Mnemiopsis leidyi* is found from upper oligohaline to the polyhaline zone, primarily in warm months. Its abundance may be reduced in polyhaline waters due to predation by the atentaculate ctenophore *Beroe ovata*.

Salinity Relationships:

Mnemiopsis is most abundant in the mesohaline and polyhaline zones, and is rarely found below 4-5‰. In summer it is most numerous, and its range extends to the oligohaline region (4-5‰). In winter and early spring it is restricted to salinities of 11‰ or above. An important late summer and fall predator, *Beroe ovata*, is itself found only down to 16‰. Extension of the polyhaline zone upestuary due to flow reductions would allow

Beroe to extend its range in the Bay. During the 1964-65 drought, *Beroe* was collected in the lower Patuxent River (Herman et al. 1968). Other predators, notably the butterfish *Peprilis triacanthus* and the harvestfish *P. alepidotus* are again inhabitants of the more saline Bay areas. *Mnemiopsis* is also eaten by the sea nettle *Chrysaora,* although such predation has only moderate effects on *Mnemiopsis* numbers (Burrell and Van Engel 1976).

Other Sensitivities:

Mnemiopsis is also affected by temperature. Lower temperatures reduce fecundity, and below 10°C, no eggs are laid (Kremer 1975).

Trophic Importance:

While Mnemiopsis is itself a relatively minor source of food for other organisms, it is a voracious predator on zooplankton. Presence of large numbers of Mnemiopsis can virtually eliminate copepods from the same area (Burrell 1972). The cydippid larvae of Mnemiopsis has tenacles, and feeds by capture. The adult ctenophore feeds by impinging prey on the oral lobes by use of ciliary currents, and entangling it in mucous strands. The feeding rate of the adults is linearly proportional to the concentration of prey. Food ingested beyond the needs of the organism are ejected in a mucous bolus, thus also killed. Mnemiopsis may also take some detritus and large phytoplankton, but needs animal food for long term survival (Baker & Reeve 1974). Mnemiopsis excretes a large proportion of its injested organic N & P, and is thus also important to nutrient cycling.

Selection Factors:

- Importance as a predator on zooplankton.
- Importance to nutrient cycling.

- Sensitivity to higher salinity predators whose range could be extended by low freshwater inflow.

Sources:

Baker and Reeve 1974

Bishop 1967

Burrell 1972

Burrell and Van Engel 1976

Cargo and Schultz 1967

Herman et al. 1968

Kremer 1975, 1976, 1979

Lippson 1973

Lippson et al. 1979

Mihursky and Boynton 1978

Miller 1970, 1974

Reeve and Walter 1978

Swanberg 1974

Chrysaora quinquecirrha - Sea nettle Jellyfish (Map#15)

Description:

The sea nettle is a moderately large jellyfish of the family Pelagiidae. Like all of this group it exhibits alternation of generation between the pelagic medusa form (the familiar sea nettle) and the small sessile epibenthic polyp. The medusa ranges up to 200 mm in bell diameter, with 24-72 trailing tentacles well-armed with nematocysts, and four frilled trailing oral lobes. The usual color is white, but pink or red individuals occur, particularly in the lower Bay. The cryptic polyp is only about 4 mm high, with 16-20 tentacles, found attached to hard substrates.

Range:

Chrysaora quinquecirrha is found in warm temperate areas worldwide. It apparently reaches its maximum abundance in estuaries such as Chesapeake Bay. In the Chesapeake it occupies differing areas depending on life stage and season. The medusa is found during the warmer months, (particularly July and August) in mesohaline and polyhaline areas. It reaches highest numbers in the mesohaline tributaries, rather than the Bay mainstem. Interestingly enough, despite the economic effect of this species in restricting recreation,good biomass and abundance data is lacking for virtually every area of the Bay. The year-to-year abundance seems extremely variable.

Eggs and sperm released by the medusae produce ciliated planula larvae, which settle on appropriate hard surfaces and give rise

to the sessile polyp stage. Polyps form resting cysts in cold months, or when conditions are unfavorable. One polyp may form numerous cysts. Through asexual reproduction the polyps produce ephyrae, which are released in early summer when water temperatures reach 20°C. These ephyrae grow and mature into medusae, completing the cycle. Medusae first appear in numbers in Bay tributaries, eventually occurring in the mainstem.

Salinity Relationships:

The medusae are rarely found at salinities below 5‰. Polyps have an even more restricted salinity range, and occur generally between 7-20‰ where suitable habitat exists.

Freshets which reduce salinities over a relatively long time span can kill the polyps, thus reducing later medusa abundance, as in 1972 after Tropical Storm Agnes.

Other Sensitivities:

The medusae are also limited by temperature, and are generally found above 20°C. Polyps encyst at temperatures below 4°C, and produce ephyrae above 20°C. Polyps are also limited by their need for hard substrates, and are thus additionally affected by sedimentation. Anoxic or hypoxic conditions in summer in deep water, as well as preponderance of soft substrate, tends to limit polyps to less than 10 m depth. However, they can occur more deeply in areas of high dissolved oxygen and good circulation.

Trophic Importance:

Both polyps and medusae feed upon zooplankton, with the powerfully armed medusae also able to capture small fish, worms, and

crustaceans. When abundant, *Chrysaora* medusa can probably exert significant grazing pressure on zooplankton populations. Clifford and Cargo (1978), estimate that a moderate sized medusa can consume approximately 18,800 copepods per day in summer. *Chrysaora* medusae also feed upon the ctenophore *Mnemiopsis*, reducing its numbers.

Few organisms eat the *Chrysaora* medusae, but among them are the butterfish, *Peprilis triacanthus*, and the harvestfish *P. alepidotus*. These fish also have a commensal relationship with *Chrysaora*, as the juvenile fish shelter within the medusa's tentacles (Mansueti 1963).

The polyp is preyed upon by various species which feed upon hydroids, particularly nudibranchs such as *Cratena sp.*. Barnacles and other planktivores have been shown to capture and ingest the ephyrae (Cones and Haven 1969).

Selection Factors:

- Economic importance of the medusae in restricting recreational use of Bay waters in summer.
- Potential of extension of range upstream in Bay and tributaries due to low flow conditions.
- Trophic importance of species as a predator of zooplankton and small fish.

Sources:

Burrell 1972
Cargo and Schultz 1966, 1967
Clifford and Cargo 1978
Cones and Haven 1969
Lippson 1973
Lippson et al. 1979
Gatz et al. 1973
Littleford 1937
Loeb 1972
Mansueti 1963
Mihursky and Boynton 1978
Miller 1970, 1974
Schultz and Cargo 1971

Brachionis calyciflorus - Rotifer (Map #16)

Description:

Brachionis calyciflorus is a small (less than 0.5 mm) planktonic rotifer of the family Brachionidae.

Range:

Brachionis calyciflorus is found worldwide in temperate fresh and oligohaline areas. In Chesapeake Bay, it is most abundant in tidal freshwater, although it may extend into oligohaline salinities, particularly in spring. Numbers may reach 200,000 individuals or more per m^3 in late spring.

Brachionis exhibits parthenogenetic reproduction, as do most rotifers. Females produce unfertilized diploid amiotic eggs which hatch into females. Miotic eggs can be produced under unfavorable conditions. They are haploid; if unfertilized, they produce males; if fertilized, they become heavy-walled dormant eggs, from which females hatch. This species has a short maturation period and potential for rapid population growth, and this probably is of considerable importance in the ecosystem.

Salinity Relationships:

B. calyciflorus is found from the head of tide to low oligohaline areas. In Chesapeake Bay, it is densest at salinities less than

0.5‰, but can be found up to 5‰ or so. In the laboratory, maximum growth of cultures occurs below 4‰, and reproduction is retarded at 6‰; salinities of 8‰ are lethal (Spektorova et al. 1975).

Other Sensitivities:

B. calyciflorus is probably sensitive to temperature changes, but its ideal range is not known. A closely related species, *B. plicatilis*, shows an optimum range of about 16 - 27 °C. Spektorova et al. emphasize that the concentration of suitable food was most important for maintainence of populations of *B. calyciflorus*.

Potential Habitat:

For this species is defined as areas 5‰ salinity or less.

Trophic Importance:

B. calcyiflorus feeds upon small phytoplankters (usually less than 10μ in diameter), bacteria, and suspended detritus. Rotifers and other microzooplankton are the primary grazers on nannoplankton, and represent a key link in converting nannoplankton productivity to food for higher trophic levels.

This rotifer is an important food for larval fishes, particularly the smaller species. *B. calyciflorus* was found to represent 42.6% of food in the stomachs of striped bass yolk sac larvae (Beaven and Mihursky 1980). Its abundance in the major spawning and nursery areas makes *Brachionis* a particularly important organism in the trophic system.

In general, the importance of rotifers to aquatic food chains is recognized, but not well quantified. The abundance and rapid turnover times of such organisms indicate that they play a major role in nutrient recycling, as well as energy transfer.

Selection Criteria:

- Sensitivity to salinity, and potential restriction of range due to low flow conditions.
- Abundance and trophic importance, particularly to larval fish.

Sources:

Beaven and Mihursky 1980
Burbidge 1974
Chotiyaputta and Hirayama 1978
Dahlberg et al. 1973
Goodwin 1970
Grant and Berkowitz 1979
Hirayama and Kusano 1972
Johns Hopkins Univ. 1972
King 1967
Sage et al. 1976
Spektorova et al. 1975

Acartia clausi - Copepod (Map #17)

Description:

Acartia clausi is a small (~ 1 mm) calanoid copepod of the family Acartiidae. It is extremely abundant seasonally in Chesapeake Bay.

Range:

A. clausi is an estuarine and neritic species of cool temperate/ boreal affinities, typically most abundant in near-shore areas. In Chesapeake Bay, the species occurs only during the winter/ early spring months when water temperatures are suitable for its reproduction. It is generally more important numerically, and more persistent in the higher salinity areas of the estuary. In Chesapeake Bay it is a winter-spring codominant with its congeneric A. tonsa. In mesohaline regions, A. clausi first appears in late November or December, reaches maximum abundance (~ 5-10,000 individuals m^3) in March, and is gone from the plankton by May. In the polyhaline lower Bay, the species can reach densities of over 20,000 organisms per m^3 and constitute over 99% of the total zooplankton in March and April. It generally persists until June in these areas.

Salinity Relationships:

A. clausi is not as tolerant of reduced salinities as is A. tonsa : reaches its maximum abundance in the Bay at salinities greater [illegible]. However, it can be found down to 3‰ in the upper Bay

and tributaries. Above ~ 18‰ it is sometimes reduced in numbers by influx of neretic carniverous zooplankton from the shelf (Grant and Olney 1979), although polyhaline salinities do not limit its distribution.

Sensitivity and Potential Habitat:

A. clausi is limited by temperature in Chesapeake Bay. In general, temperatures above 20°C are not favorable to reproduction and survival. Between 11° and 18°C, A. clausi appears to be at a competitive disadvantage in relation to A. tonsa in lower salinity water. For this reason, the observed succession of tonsa over clausi in spring occurs first in the upper Bay and tributaries and proceeds downbay. A. clausi filters more efficiently and respires less than A. tonsa at low temperatures (Anraku 1964). It can reproduce at temperatures as low as 4°C.

Trophic Importance:

A. clausi is a selective filter feeder on phytoplankton and detritus and also exhibits a certain amount of selective raptorial feeding on small zooplankton (including nauplii of various copepods). It can adjust its feeding strategy to take advantage of the most numerous size class of phytoplankton available, and can "track" the various biomass peaks so as to maximize feeding efficiency. There is also a tendency to select for the larger particles. Adults feed less efficiently on particles smaller than 6-8 μ . When abundant, A. clausi can exert a significant grazing pressure on the phytoplankton populations.

The two Acartia spp. are important contributors to the estuarine food web. Although A. clausi is not found in the major fish nursery areas, it nevertheless is used as food by juvenile fish, and carnivorous zooplankton such as jellyfish and ctenophores.

A. clausi also acts as a source of regenerated nutrients (primarily N & P), as do other zooplankton.

Selection Factors:

- Trophic importance, both as a grazer and as a source of food for other organisms.
- Potential expansion of range due to increased salinity up-Bay.

Sources:

Acad. Nat. Sci. Phila. 1977, 1978
Anraku 1964
Burrell 1972
Goodwyn 1970
Grant and Olney 1979
Heinle 1966, 1967
Herman *et al*. 1968
Jacobs 1978
Richman *et al*. 1977
Rupp 1969
Sage and Olson 1976
Storms 1975

Acartia tonsa - Copepod (Map #18)

Description:

Acartia tonsa is a small (∿ 1 mm) calanoid copepod of the family Acartiidae. This is one of the most abundant and widespread zooplankter found in Chesapeake Bay.

Range:

Acartia tonsa is a eurytopic species, occurring worldwide in temperate areas. It is most abundant in estuarine nearshore areas, and also occurs in hypersaline lagoons. In Chesapeake Bay, A. tonsa is found year round, although it is typically most abundant in summer, and is by far the dominant copepod in Chesapeake Bay. While the species is found from tidal freshwater to the polyhaline Bay mouth, it occurs in greatest numbers in salinities over 5‰.

In summer, high densities may extend upstream to 1 or 2‰. Maximum numbers of adult copepods per m^3 may reach 100,000, but more typical values range between 5,000 and 20,000. Numbers of copepodites and nauplii can be considerably greater. A. tonsa often constitutes 90% or more of the total zooplankton biomass. Acartia can be severely reduced in number in summer by the predaceous ctenophore Mnemiopsis, found between 5 and 20‰ salinity. The extent of Acartia tonsa penetration into low oligohaline areas and tidal freshwater is not thoroughly known, but 0.5‰ is close to the lower limit for this species. Acartia is less numerous

and a less important zooplankton constituent at the Bay mouth, where a number of neritic copepod species occur with it.

Salinity Relationships:

Acartia tonsa is a euryhaline species, although physiologically it may be more efficient at salinities of around 15 ‰ (Heinle, pers. comm.). Minimum salinities in warm months are near 0.5 ‰; in winter, the species is more restricted and the minimum is closer to 2 - 3‰. The species is found in hypersaline lagoons along the Gulf coast, where it may benefit from lack of competitors and predators.

Sensitivity and Potential Habitat:

Reproduction by *A. tonsa* is limited by temperature, below 10°C, production of young is minimal. *A. tonsa* filters less efficiently and respires more at low temperatures than does *A. clausi*. The upper temperature limits for reproduction and survival of *A. tonsa* (about 30-35°C) are rarely reached in the Bay, except near thermal outfalls.

Trophic Importance:

As the single most abundant and widespread zooplankton in Chesapeake Bay, *Acartia tonsa* must be considered a key link in many Bay food webs. As a grazer-predator, it can exert tremendous pressure on phytoplankton stocks; at times of peak abundance, 50% of the daily primary production can be consumed by this species (Heinle 1966). In addition, it may enhance itself competitively by feeding selectively on nauplii of other copepod species. It also influences the regeneration of nutrients, both through direct excretion or release of N and P, and by produciton of fecal pellets which are sources of food for bacteria and meiofauna.

A. tonsa is a major source of food for planktivorous organisms (especially larval and juvenile fish and invertebrates), suspension-feeders, carnivorous zooplankton (such as jellyfish, ctenophores, or chaetognaths), and plantivorous fish such as menhanden or anchovies.

Selection Factors:

- Trophic importance as a key link in most phytoplankton based food webs in Chesapeake Bay.
- Abundance and dominant biomass position in zooplankton community.

Sources:

Acad. Nat. Sci. Phila. 1977, 1978
Allan et al. 1976
Anraku 1964
Burrel 1972
Ecological Analysts 1974
Goodwyn 1970
Grant and Olney 1979
Grant and Berkowitz 1979
Heinle 1966, 1969, unpubl.
Herman et al. 1968
Jacobs 1978
J.H.U. 1972
Lonsdale et al. 1979
Olson and Sage 1978
Rupp 1969
Sage and Olson 1976
Sage et al. 1977
Storms 1975

Eurytemora affinis - Copepod (Map #19)

Description:

Eurytemora affinis is a small (∿ 1 mm) calanoid copepod of the family Temoridae. It is an abundant organism in the tidal freshwater and oligohaline zones of the Chesapeake Bay.

Range:

Eurytemora affinis is an estuarine endemic found in temperate areas. In Chesapeake Bay, Eurytemora is found throughout the year, although it is more abundant and has the greatest range in spring. In summer months, this species is restricted to oligohaline and tidal freshwater areas. Lack of zooplankton information from most of the eastern shore tributaries necessitates defining these areas as potential habitat for Eurytemora affinis.

Salinity Relationships:

In spring months, Eurytemora occupies a salinity range from 0 to about 12‰. Maximum abundance, about 50 to 100,000 individuals per m^3, occurs in the area where salinities are less than 10‰. As temperatures rise in late spring, the numbers of this species decline, and it disappears from the higher salinity areas. At this time, maximum abundance (about 1000 - 5000 individuals/m^3) is found below 4‰.

Sensitivity and Potential Habitat:

Eurytemora affinis is a species with north temperate origins (Jeffries 1962), and this is reflected in its reduced range and abundance in summer. Competition with Acartia tonsa was once proposed as the mechanism restricting E. affinis to low salinity regions in warmer months. However, the observed decline in abundance of Eurytemora begins before A. tonsa numbers increase dramatically (Sage, pers. comm.). Competition could still be a factor, however, since A. tonsa has been shown to feed upon the nauplii of E. affinis (Lonsdale et al. 1979).

Trophic Importance:

Eurytemora affinis is probably the single most important zooplankter in the oligohaline and tidal fresh nursery grounds of many fish. It has been shown to be particularly important to alosids (Burbidge 1972) as well as moronids (Polgar et al. 1976, Setzler et al. 1979, Beaven and Mihursky 1980). Abundance of Eurytemora is important for survival of striped bass larvae (Setzler et al. 1979), as it can constitute 72% of their food (Beaven and Mihursky 1980).

Eurytemora is a selective filter feeder, and feeds upon algae and detritus. Like Acartia, it "tracks" biomass peaks to maximize feeding efficiency, but does not show raptorial feeding on larger particles. When algal production is insufficient to meet carbon requirement for this species, it utilizes detritus (Allan et al. 1977). Delivery of marsh detritus to the lower estuary by spring runoff is important to Eurytemora biomass in this time period.

Selection Factors:

- Trophic importance to larval fish survival.
- Restricted salinity range, and vulnerability to low flow salinity increases.

- Importance of runoff to detrital input.

Sources:

Acad. Nat. Sci. Phila. 1977, 1978
Allan *et al*. 1977
Beaven and Mihursky 1980
Burbidge 1972
Burrell 1972
Conte and Otto 1980
Ecological Analysts 1974
Goodwyn 1970
Grant and Berkowitz 1979
Herman *et al*. 1968
Jefferies 1962
J.H.U. 1972
Lippson *et al*. 1979
Lonsdale *et al*. 1979
Olson and Sage 1978
Polgar *et al*. 1976
Sage and Olson 1977
Sage *et al*. 1976
Setzler *et al*. 1979
Storms 1975

Scottolana canadensis - Copepod (Map #20)

Description:

Scottolana canadensis is a harpactacoid copepod of the family Canuellidae. It is an elongate form about 1.5 - 2.0 mm long, typically epi-benthic, but seasonally abundant in the zooplankton. In many collections it has been confused with the much smaller Halectinosoma curticorne, also an abundant species in the Bay (Sage, pers. comm.). For this reason, there is a certain amount of conjecture regarding some of its distribution records.

Range:

Scottolana is an estuarine endemic species, reaching its greatest abundance in the oligohaline portions of temperate-zone estuaries. In the Chesapeake, Scottolana is most abundant in late spring and summer, and extends its range furthest downstream at this time, into low mesohaline regions. Collection records tend to show a much greater abundance of copepodites, than adults in the plankton; this is probably an artifact due to net evasion by the adult animals (Gauzens, pers. comm.). Collection information for this species is lacking in many of the eastern shore tributaries. It is probable that it exists in all suitable habitats within the Bay.

Although considered a benthic species, and a member of the meio-fauna, there is a great paucity of information on Scottolana's

benthic role. It is probable that it overwinters and spends part of its life cycle on the bottom but there is apparently no information as to depth and sediment preferences, if any. This reflects the general lack of knowledge about meiofaunal composition and distribution in Chesapeake Bay.

Salinity Relationships and Potential Habitat:

Scottolana reaches its greatest abundance (up to 100,000 individuals m^3, but usually an order of magnitude less) between the salinities of 1.0 to 5.0 ‰ or so. It is found in salinities up to 10 ‰ or slightly more, and also in tidal freshwater, but at reduced densities. The extent of this species' range into lowest salinities is uncertain, but it is not a characteristic member of the freshwater zooplankton.

Trophic Importance:

Scottolana and other harpacticoids are considered one of the major foods for juvenile sciaenid fishes, as well as other benthic feeders. For example, Stickney *et al*. (1975) found harpacticoides in 88% of spot stomachs examined, the single most numerous item. The coincidence of *Scottolana*'s range with major nursery areas is of particular importance.

Selection Factors:

- Restricted salinity tolerance of this species, and potential reduction of range under low flow conditions.
- Importance as food for demersal feeding juvenile fish, particularly Sciaenids.

Sources:

Acad. Nat. Sci. Phil. 1977, 1978
Burrell 1972
Heinle *et al*. 1975
Lippson 1973
Lippson *et al*. 1979
Sage and Olson 1976
Stickney *et al*. 1975

Bosmira longirostris - Cladoceran (Map #21)

Description:

Bosmina is a small, primarily freshwater cladoceran of the family Bosminidae. This species has a rounded body, and appendages adapted for swimming and filtering food. The head is extended forward and down into a pointed horn, hence "longirostris."

Range:

This species is widespread in temperate rivers and lakes. In Chesapeake Bay, it is restricted to freshwater and oligohaline reaches of tributary rivers and the Bay mainstem. Bosmina occurs throughout the year, but is most abundant in spring and summer. At that time it achieves its maximum extension downstream. Densities may often exceed 100,000 or more individuals per m^3, particularly in lowest salinities.

Like all cladocerans, Bosmina exhibits parthenogenic reproduction for most of the year.

Salinity Relationships and Potential Habitat:

Bosmina reaches its greatest abundance in freshwater, and is reduced in number when salinities exceed 0.5 to 1.0‰. It generally does not occur in salinities over 5 ‰.

Trophic Importance:

Bosmina is a filter feeder, ingesting algae, bacteria, and detritus. This species is an important source of food for larval fish, as it is one of the most numerous zooplankters in the freshwater nursery areas. It was found to comprise up to 65% of food in the stomachs of larval striped bass from the Potomac River (Beaven and Mihursky 1980). It is also an important item of food for larval and juvenile alosids, such as the blueback herring (Burbidge 1972) when it is abundant.

Selection Factors:

- Importance as food for larval and juvenile fish in tidal freshwater nursery areas.
- Sensitivity to potential increases in salinity, due to low flow conditions, with corresponding reduction of range.

Sources:

Beaven and Mihursky 1980
Burbidge 1972
Ecological Analysts 1974
Goodwyn 1970
Herman *et al*. 1968
Lippon *et al*. 1979
Sage *et al*. 1976
Zhdanova and Frinooskaya 1975

Evadne tergestina - Cladoceran (Map #22)

Description:

Evadne tergestina is a marine cladoceran, of the family Podonidae (Polyphenoidea). It has an angular, pointed body with a single large eye and appendages adapted for seizing the large dinoflagellates, and small zooplankton (ciliates, rotifers, and copepod nauplii) upon which it feeds.

Range:

E. tergestina is a neretic species found worldwide in warm temperate seas. In Chesapeake Bay, E. tergestina occurs only in the lower Bay, and is most abundant in summer months. At these times, it can represent a major fraction of the zooplankton biomass, with densities often exeeding 100,000 individuals per m^3. During the 1960's drought, Evadne was recorded as far north in the Bay as Calvert Cliffs; typically, however, it is restricted to Virginian waters (Bosch & Taylor 1968).

Salinity Relationships:

Evadne tergestina is a relatively stenohaline species, and is not found at salinities much below 16‰. Maximum densities occur at 20‰ salinity and above.

Sensitivity and Potential Habitat:

Evadne tergestina enters the Bay only when temperatures are near the summer maximum. They disappear rapidly in early fall, at least partially due to predation by Chaetognaths, as well as falling water temperatures.

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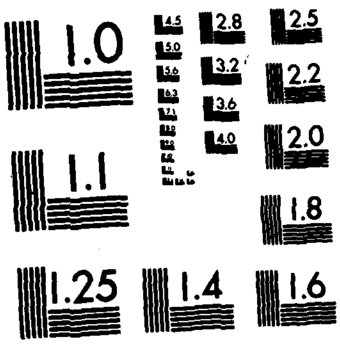

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Tropic Importance:

During its period of maximum abundance, *E. tergistina* could exert a significant feeding pressure on microzooplankton, as well as copepod nauplii and copepodites, and large dinoflagellates. In turn, they represent an important source of food for larger predacious plankton, larval and juvenile fish, and planktivorous adult fish.

Selection Factors:

- Restricted salinity range, and demonstrated increased penetration into the Bay during periods of low flow.
- Trophic importance.

Sources:

Bosch and Taylor 1968
Bryan 1977
Jacobs 1978

Podon polyphemoides - Cladoceran (Map #23)

Description:

Podon is one of the few marine cladocera, and is a member of the family Podonidae. It is characterized by a rounded body, large single eye, and appendages adapted for swimming and grasping prey (it feeds upon large phytoplankton and small zooplankters such as rotifers and naupleii).

Range:

Podon is an estuarine endemic species, found worldwide where environmental conditions are suitable. In Chesapeake Bay it is most abundant in the mesohaline regions of the estuary. Podon first appears in tributaries when spring water temperatures reach 6°C, hatching from overwintering eggs. Numbers increase through parthogenetic reproduction, although sexual forms appear as temperatures reach 11°C (rarely amounting to more than 10% of the population). Highest densities of Podon occur in the Bay mainstem, during the time when water temperatures remain below 27°C. The species disappears when temperatures exceed this value, only to reappear in fall as the water cools. Eggs produced by sexual forms in the autumn overwinter to produce the next year's spring animals.

Maximum densities may reach 100,000 individuals per m^3, although densities an order of magnitude smaller are more usual.

Salinity Relationships:

Parthenogenetic females are most abundant between the salinities of 8 and 18‰ with a maximum tolerance of 31.5‰. Males and sexual females are found between the salinities of 4 and 20‰.

Sensitivity and Potential Habitat:

Podon is, as was discussed above, also limited by low temperatures in winter (rare at temperatures below 6°C) and high temperatures in summer months (over 27°C). Sexual forms have an even more restricted tolerance, and are found generally when water temperatures are between 11 and 23°C.

This species exhibits diurnal vertical migration, and apparently uses the upstream flow of water at depth to maintain itself within the estuary. Low flow could alter this circulation pattern.

Trophic Importance:

Podon may reach densities in June and October of over 100,000 individuals per m^3. When this abundant, *Podon* can exert a significant grazing effect on the phytoplankton and microzooplankton on which it feeds. Also, it can represent a major source of food for larval fish and crabs, as well as planktivorous fish. It is also preyed upon by ctenophores and coelenterates, such as *Mnemiopsis*.

Selection Factors:

- Sensitivity to salinity and circulation, both potentially affected by low flow.
- Trophic importance, both as source of food for larval fish, and as grazer/predator on large phytoplankton and microzooplankton.

Sources:

Bosch and Taylor 1968, 1973a, 1973b

Bryan 1977

Goodwyn 1970

Herman *et al*. 1968

Jacobs 1968

JHU 1972

Lippson *et al*. 1979

Limnodrilus hoffmeisteri - Oligochaete worm (Map #24)

Limnodrilus hoffmeisteri is an oligochaete worm of the family Tubificidae. It is a long slender worm about 0.5 - 2.5 cm in length, often occuring in high densities in Chesapeake Bay.

Range:

L. hoffmeisteri is found worldwide in fresh and olighohaline temperate areas. In Chesapeake Bay it is restricted to the fresher parts of the tributaries and main Bay. Numbers are often very high, particularly in areas of organic enrichment, to 15,000 individuals/m^2 or more. Although 100 - 2000/m^2 is more typical. In some polluted areas, L. hoffmeisteri and its congenerics are the only abundant benthic fauna (Pfitzenmeyer 1975).

L. hoffmeisteri reproduces twice a year in European waters, from May - June and from late September to early October (Poddubnaya 1973). Eggs are brooded for a time in a cocoon, which is later deposited on the bottom by the adults. The young worms hatch, grow rapidly, and spring young may reach sexual maturity by fall in warmer areas. Adult worms apparently die after reproduction, accounting for a decrease in adult abundance in summer and winter (Poddubnaya 1973). It is not known if the same pattern is found in Chesapeake Bay. Crumb (1977) found L. hoffmeisteri population to increase in spring, with peak numbers of juveniles by June. Densities decreased in August, possibly due to high temperatures, and these lower densities persisted throughout winter.

Salinity Relationships:

Laboratory experiments have shown L. hoffmeisteri to withstand salinities from 0 - 10.7 ‰, with the 168 hr LC_{50} being 14.7 ‰ (Birtwell and Arthur 1979). In the Thames it was found downstream to areas which experienced salinity variations up to 13.5 although the mean salinity where it was the dominant species was 3.9 ‰. However, in Chesapeake Bay, L. hoffmeisteri is rarely found above 5‰, and generally occurs at salinities below 1.0 ‰ (Diaz 1977, 1979, Cory and Dresler unpubl.). In the Patuxent River it occurs further downstream, and shows a bimodal distribution, with maximum abundance below 1‰ and then again near the discharge from Chalk Point S.E.S., at around 5‰ (Holland et al. 1980). Thus, under suitable conditions, L. hoffmeisteri can be found in salinities well above its usual range.

Other Sensitivities:

Limnodrius hoffmeisteri is a very tolerant organism and is considered an indication of organic enrichment (Brinkhurst 1970). Birtwell and Arthur (1979) found it able to withstand temperatures up to 37.5°C, and predicted that it could exploit habitats adjacent to thermal outfalls, as Holland et al. (1980) observed. However, temperatures of 20 - 25°C are more optimal for the species (Appleby and Brinkhurst 1970). In fact, Crumb (1977) reported a steep decline in Limnodrilus numbers as bottom temperatures in the Delaware River reached the 28 - 32°C range. He proposed that high temperatures may limit its populations in the river.

Although L. hoffmeisteri is found in all sediments, including gravel and pebbles, it is much more abundant in soft organic rich muds (Crumb 1977, Birtwell and Arthur 1979, Diaz 1979).

The species is also tolerant of considerable anoxia (Crumb 1977, Birtwell and Arthur 1979), and would thus be able to exploit the normally hypoxic summer conditions in many Bay tributaries.

Limnodrilus hoffmeisteri is thus an opportunistic species, able to colonize and exploit stressful habitats. When possible competitors or predators are absent (due to unfavorable conditions), it may occur well outside its expected range.

Potential Habitat:

Potential habitat for this species is defined as areas from freshwater to 1.0‰, up to 5 ‰ under certain conditions, all depths and all sediments, but most abundant in mud.

Trophic Importance:

L. hoffmeisteri is a deposit feeder, ingesting detritus and its associated bacteria and microfauna. It feeds head down in its burrow, with the caudal end projecting (and undulating) above the sediment surface. In fresh water areas, where they are the dominant infauna, *L. hoffmeisteri* and other oligochaetes, are probably most important in the transfer of detrital and bacterial energy to higher trophic levels (Diaz 1979). They are used as food by birds, fish, and numerous smaller predators such as insect larvae, which are in turn food for fish. In estuarine areas where smaller oligochaete species are found, and polychaetes become numerous, the trophic importance of the group declines (Diaz 1977). However, in polluted or disturbed areas, they again may represent a key trophic link.

Limnodrilus is also important in its effect on sediment structure. Sediment is ingested in subsurface layers, and egested on the surface. Sediments may be turned over to a depth of 4 - 6 cm up to a dozen times annually (Appleby and Brinkhurst 1970). The activities of oligochaetes also has implications for the regeneration or relase of nutrients from the sediments to the water column (Diaz 1979). Lastly, burrowing activity may increase oxygenation of the upper centimeters of sediment.

Selection Factors:

- Abundance and faunal dominance in tidal freshwater and oligohaline areas.
- Importance to bioturbation of sediments in these waters.
- Key link in detrital/bacterial food web in these areas.

Sources:

Appleby and Brinkhurst 1970
Birtwell and Arthur 1979
Brinkhurst 1970
Cory and Dresler unpubl.
Crumb 1977
Diaz 1977, 1979
Ecological Analysts 1974
Holland *et al*. 1980
Lippson *et al*. 1979
Pfitzenmeyer 1973, 1975, 1976
Poddubnaya 1973
Reinharz *et al*. unpubl.

Heteromastus filiformis - Polychaete Worm (Map #25)

Description:

Heteromastus filiformis is a long, slender burrowing polychaete of the family Capitellidae. It is a narrow worm about 40 - 70 mm long, with few obvious polychaete-like appendages, apointed head-region (superficially resembling an oligochaete), and is purplish-red in color. H. filiformis inhabits a mucous-lined burrow in intertidal or subtidal areas.

Range:

H. filiformis is found from New England south to Flordia, and also occurs in Europe. In Chesapeake Bay, it occurs from the oligohaline zone to the Bay mouth, and may be very abundant: densities are usually around 500/m^2 or less, but numbers of 2000 adults per square meter have been recorded. Recruitment of over 50,000 juveniles/m^2 into exclosure cages was reported by Virnstein (1979). The species is tolerant of eutrophication and thermal discharges, which, coupled with its planktonic larvae and rapid growth rate, mark it as a euryhaline opportunist (Wass et al. 1972, Grassle & Grassle 1974).

H. filiformis begins breeding in early spring in Chesapeake Bay. Loi and Wilson (1979) record sexually mature adults containing gametes in March. The species has a planktonic larvae, and

recruitment is at a peak in June and July. *H. filiformis* is probably reproductively active for much of the year. Typically the species shows considerable temporal and spatial variability in its distribution (Watling 1975, Loi and Wilson 1979, Virnstein 1979), although there appears to be little seasonal variation in Patuxent River populations (Holland *et al*. 1980).

Salinity Relationships:

H. filiformis is a euryhaline species and collection records show it occurs in salinities as low as 2 ‰ in Chesapeake Bay. However, densities decrease rapidly below 5‰. It occurs in full oceanic salinities, as well.

Other Sensitivities:

Heteromastus filiformis is found in a variety of substrates from sand to mud, although many authors report that it occurs with greatest frequency in muddy sediments (Watting 1975, Kinner and Maurer 1978, Maurer *et al*. 1978). This may reflect its deposit-feeding mode of life (and need for organic-rich sediments), rather than any strict substrate requirement. Tenore (1970) reported that *H. filiformis* occurred only in sand substrates in Pamilico Sound. Dauer *et al*. (1979) also found *H. filiformis* more abundant in sand in the Lynnhaven River.

The species occurs with greatest frequency in shallow areas, although it has been reported at great depths offshore (Kinner and Maurer 1978, Holland *et al*. 1979, Loi and Wilson 1978). The depth limitation in Chesapeake Bay is probably related to summer anoxia (Holland *et al*. 1977).

H. filiformis is eurytopic in regard to temperature. Mature gametes occur in worms in March at Calvert Cliffs, when ambient

water temperatures is about 7 - 8°C, and the species breeds for much of the year. Although Wass et al. (1972) indicate that the species is quite tolerant to thermal pollution, Holland et al. (1980) do show a reduction in numbers at stations affected by discharge from Chalk Pt. S.E.S. relative to control stations. However, no information on exact physiological temperature limits appears available for this species.

Potential Habitat:

Potential habitat for this species is defined as areas greater than 2 ‰ salinity, to 10 meters, most abundant above 5‰ and in less than 6 - 7 meters depth.

Trophic Importance:

Heteromastus filiformis is a deposit feeder, ingesting detritus, algae, microorganisms, and decaying matter from below the surface. It is found oriented vertically, head-down, in its tube; waste material and sediment are deposited on the substrate surface as a small cone.

H. filiformis is fed upon by fish and crabs, although it is able to avoid some predation by deep burrowing (Virnstein 1979). Densities of *H. filiformis* in exclosure cages were significantly higher than controls at many stations (Virnstein 1979, Holland et al. 1979).

Heteromastus filiformis is an opportunistic species, and might be expected to increase in abundance quickly upestuary if salinities increase due to low flow. Dean and Haskin (1964) reported it as a pioneer species in recolonization of a previously polluted area; however, it was replaced within a year in many areas by other species.

The deep burrowing and tube building of this species contributes to sediment reworking, sorting, nutrient regeneration and release.

Selection Factors:

- Abundance of species, and dominant position in many areas.
- Importance ot predators, sediment reworking and detrital breakdown.
- Potential colonizer of disturbed areas.

Sources:

Boesch 1971, 1977 unpubl.
Cory and Dresler unpubl.
Dauer *et al*. 1979
Dean and Haskin 1964
Diaz 1977
Grassle and Grassle 1974
Harman unpubl.
Hartman 1945
Holland *et al*. 1977, 1979, 1980
Kinner and Maurer 1978
Loi and Wilson 1979
Maurer *et al*. 1978
Pfitzinmeyer 1970, 1975
Reinharz *et al*. unpubl.
Tenore 1970
Virnstein 1979
Wass *et al*. 1972
Watling 1975

Pectinaria gouldii - Polychaete worm (Map #26)

Description:

Pectinaria gouldii* is a large tube-building polychaete of the family Amphictenidae; popularly known as the trumpet worm because of its long conical-shaped tube. The tube is about 2 - 5 cm in length, depending on the size of the animal, and constructed of a single layer of sand grains firmly cemented together. The most notable feature of the animal are the two sets of long golden paleae or setae on the head, which are used for digging or as an operculum for the tube. The head is also equipped with numerous tentacles which are used in feeding and tube building.

Range:

Pectinaria gouldii is found from New England to North Carolina in inter- or subtidal areas. In Chesapeake Bay, it is confined to high mesohaline and polyhaline regions. Its distribution is spotty and variable within its range, and densities are usually less than $500/m^2$, although numbers of $4000/m^2$ or more have been recorded (chiefly young worms).

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*Note: Because of confusion about the type specimen for the genus, the name Pectinaria has been recently replaced by Cistena. However, as this change has been appealed to the International Commission on Zoological Nomenclature, the more familiar name is retained for this report.

The tube of *P. gouldii* is permanent, and the animal will not leave it.; Watson (1927) characterized it as the organism's "life work". The animal is typically found buried in an oblique position below the substrate surface, with the tapered end of the tube projecting for a centimeter or so above the surface. The animal digs with its paleae, and sediment is conveyed to the mouth by the tentacles. The activities of the worm form small collapsing caverns or channels which fill in with surface sediment (Watsen 1927, Gordon 1966), thus constantly reworking the substrate.

P. gouldii appears to spawn once a year in Chesapeake Bay, probably in late spring (Virnstein 1979). Larvae are pelagic; they first settle to the bottom and build a small chitinous tube (Watson 1927). This forms the base of the later adult tube. Recruitment is irregular, but several thousand young worms per square meter may in late May or June settle. Growth is relatively rapid, the worms reaching adult size by autumn (Virnstein 1979). Loss to predation is high, however, and few worms live to two years of age (Peer 1970).

Salinity Relationships:

There are apparently no laboratory studies of the exact physiologically tolerances of *P. gouldii*, at least in regard to salinity. However, collection information form Chesapeake Bay indicates that it is not found in salinities much below 10‰, and is most abundant at 15‰ or above. This is the expected range of a eurytolerant marine species such as *Pectinaria gouldii*.

Other Sensitivities:

Like all organisms, *P. gouldii* is affected by temperature. Optimal

and lethal temperatures for this species have apparently not been determined, but spawning appears initiated when spring temperatures reach $15^{\circ}C$ or so. Rate of sediment working (feeding) and respiration are also temperature-dependent, and reach very low levels in winter (Gordon 1966, Nichols 1975).

P. gouldii is also somewhat sensitive to sediment type. Adult worms cannot work particles larger than 1 mm (Gordon 1966). Also, Watson (1927) reports the death of young worms of the congeneric P. koreni resulting from clogging of the small end of the tube by passage of too-large-sized particles. P. gouldii is generally more abundant in fine sands, muddy sands, and sandy muds (Pfitzenmeyer 1961, Boesch 1973).

Anoxic conditions may limit Pectinaria. In Kiel Bay, W. Germany, years in which summer anoxia developed had greatly reduced recruitment of young P. koreni, and near total destruction of standing stock (Nichols 1976). Wass et al. (1972) report P. gouldii to about 30 meters in Chesapeake Bay, but summer hypoxia in many areas could be expected to reduce or eliminate populations below 15 - 20 meters (Holland et al. 1979).

Potential Habitat:

Potential habitat for this species is defined as those areas where salinity is greater than 10‰, with greatest abundance over 15‰ and from 0 to about 10 meters.

Trophic Importance:

Pectinaria gouldii is a deposit feeder, ingesting detritus and its associated microorganisms, algae, and decaying animal and vegetable matter. Gordon (1966) found that this species removed almost half of the organic matter from each gram of sediment

worked (laboratory results). The animal digs vigorously with its paleae, and the loosened sediment is conveyed to its mouth by the ciliated tentacles. Some sediment is rejected, some ingested, while some is worked and then passed through the tube by a vigorous "pumping" action of the worm's body (Watson 1927). The ejected material is deposited as a small mound at the posterior of the tube.

P. gouldii is a major prey item for bottom feeding fish and crabs and mortality due to predation is heavy. Peer (1970) estimated that 80% of the annual mortality of *P. hyperborea* was due to predation, and that 70% of a cohort was lost to predation during its first year of life. Virnstein (1979) noted that *P. gouldii* is usually not abundant in the natural environment, but that it increased several orders of magnitude in exclosure cages. He hypothesized that fish and crab predation are major factors regulating the numbers of this species.

Pectinaria is also an important bioturbator of sediments where it is abundant. In the laboratory, Gordon (1966) determined that each worm works about 6 grams of sediment per day at 18 - 19°C, with the rate decreasing with temperature. At the latitude of Cape Cod, he estimates that one worm would rework 600 grams of sediment annually (in Chesapeake Bay this rate would probably be higher). He finally concludes that at densities of 40 worms/m^2, the sediment would be completely turned over to a depth of 6 cm in four years. Also, where larger particles are mixed with finer sediment, the finer material is carried to the surface and deposited, leaving the coarser material at depth (Gordon 1966). Thus *P. gouldii* can also exert a sorting effect on natural substrates.

Selection Factors:

- Potential for range extension under low flow conditions.
- Importance as food for demersal fish and crabs.
- Importance as a bioturbator of sediments.

Sources:

Boesch 1971, 1973, unpubl.

Cory and Dresler, unpubl.

Diaz 1977

Harman, unpubl.

Holland *et al*. 1979

Kaufman *et al*. 1980

Nichols 1975, 1976

Peer 1970

Pfitzenmeyer 1961

Virnsetein 1979

Watson 1927

Wass *et al*. 1972

Scolecolepides viridis - Polychaete worm (Map #27)

Description:

Scolecolepides viridis is a burrowing polychaete worm of the family Spionidae. Adult worms are about 4 - 10 cm long, green or brownish green in color, with prominant red branchiae, and two stout tentacular palps. It inhabits a mucous-lined burrow, generally in intertidal or subtidal areas.

Range:

Scolecolepides viridis is found from Newfoundland to Georgia, in areas of reduced salinity. In Chesapeake Bay, it is confined to the oligohaline through mesohaline regions, chiefly in intertidal or shallow subtidal areas. Densities are generally less than 2000/m^2, but numbers of 10,000 individuals/m^2 have been recorded.

S. viridis breeds in early spring in Chesapeake Bay, and juvenile worms appear in May through July (Pfitzenmeyer 1970, Dauer et al. 1980). Eggs and sperm are released from ripe individuals, and planktonic larvae result. George (1966) reported that eggs cannot be fertilized, nor will they develop, at salinities under 5‰. This has implications for the species in Chesapeake Bay, as a large proportion of the population is found below these salinities, and Pfitzenmeyer (1970) consideres it one of the

three characteristic oligohaline species in the upper estuary. Dauer _et_ _al_. (1980) observed numerous ripe worms swimming at the surface at night on an ebb tide, which they consider a mechanism for dispersing breeding individuals into higher salinity areas. The resulting larvae may then be transported upestuary by bottom currents to recolonize the oligohaline zone. Larvae metamorphose at about 30 - 40 days of age, becoming negatively phototactic and testing the substrate. They eventually construct a small vertical burrow and begin a benthic existence (George 1966).

Salinity Relationships:

Scolecolepides _viridis_ is a characteristic species of the upper Bay, although it has been found regularly in upper meshohaline areas, and even occasionally in the polyhaline zone (Dauer _et_ _al_. 1980). Salinity _per_ _se_ is probably not the adult downstream limit, as much as predation or competition. Adults have been collected in salinities as low as 0.5 ‰, and occur with frequency up to 15 ‰ or so. Maximum densities occur generally between 1 - 5 ‰ in the Bay.

Larvae, as was discussed above, have definite minimum salinity limits. Eggs cannot be fertilized or early egg cleavage takes place below 5‰, although older larvae can survive 2.5‰. Eggs develop normally up to 30‰.

If adults inhabiting oligohaline areas do migrate downestuary at time of spawning, and if the resulting larvae utilize the upstream flow of water at depth to repopulate the oligohaline zone, then low flow alterations of estuarine circulation may affect the occurrence of this species in the Bay.

Other Sensitivities:

S. viridis is affected by temperature both in regard to spawning and development, and probably summer survival. It is a boreal/north temperate species, and may be limited by summer temperatures at the latitude of Chesapeake Bay. Holland et al. (1980) record that its abundance is at a minimum in summer. George (1966) found that larvae need temperatures of at least 2°C to begin development, and of 10°C to reach metamorphosis. Upper temperature limits for both adults and larvae appear to be between 34 - 35°C.

S. viridis is most numerous in firm substrates which allow tube-building, although it has been recorded from virtually all sediment types. Pearson et al. (1975) found that is was more tolerant of excess siltation than some other upper Bay species.

Potential Habitat:

Potential habitat for this species is defined as areas between 0.5‰ and 15‰, most abundant in 1‰ to 5‰, in sand and muddy sand, to 10 meters depth.

Trophic Importance:

Scolecolepides viridis is an infaunal deposit feeder, ingesting detritus, algae, microorganisms, small meiofauna, and decaying animal and vegetable matter. The worm inhabits a vertical mucous-lined burrow in firm substrates, and feeds upon the surface deposits surrounding its tube. The ciliated tentacles carry food to the pharynx, where it is ingested. The animal was abundant in organically-enriched substrates in Baltimore Harbor, including mud, so it should be considered a relatively pollution-tolerant species (Pfitzenmeyer 1975).

S. viridis is fed upon by fish, crabs and benthic invertebrates predators such as Nereis. Holland et al. (1980) suggest that the temporal pattern of the species at Chalk Pt. indicates its standing stock is controlled by predation; numbers are lowest when predators are most abundant. Caging experiments at Calvert Cliffs show that numbers inside the exclosure are significantly higher than controls only in summer (Holland et al. 1979). The lower numbers observed inside the cages at other times may reflect "internal" predation by species such as Eteone or Nereis. Homer and Boynton (1978) found that S. viridis is an important item in the diet of sport and winter flounder, and is eaten by other bottom feeding species.

As with all tube-building species, S. viridis contributes to sediment stabilization, sorting, and aeration.

Selection Factors:

- Sensitivity of reproductive cycle to salinity, and importance of estuarine circulation patterns to distribution of the species in the oligohaline zone.
- Abundance of the species in low salinity areas, and food potential for fish, crabs, birds and other predators.

Sources:

Boesch 1971 unpubl.
Cory and Dresler unpubl.
Dauer et al. 1980
Diaz 1977
George 1966
Holland et al. 1979, 1980
Homer and Boynton 1978
Lippson, A.J. et al. 1979
Lippson, R.L. unpubl.
Pearson et al. 1975
Pfitzenmeyer 1970, 1975
Reinharz et al. unpubl

Streblospio benedicti - Polychaete Worm (Map #28)

Description:

Streblospio benedicti is a small burrowing polychaete of the family Spionidae. Adult worms are only 5 - 12 mm long, reddish brown in color, with a pair of prominant ciliated tentacular palps. It inhabits a small, soft tube constructed of mucous and debris, slighcly buried into the sediment.

Range:

Streblospio benedicti is found on both the west and east coast of North America; on the east coast it occurs from New England to North Carolina. In Chesapeake Bay, it is found throughout the mesohaline and polyhaline zones. Densities are normally less than $100/m^2$, but numbers up to 5000 per square meter or more have been recorded. Extremely large numbers have set into exclosure cages, exhibiting the response pattern of an opportunistic species to available open habitat.

S. benedicti breeds primarily from April through October in the Chesapeake; the peak period of recruitment is spring (Virnstein 1979). The species is larviparous; females brood the developing embryos until approximately the ninesetiger stage. The released larvae metamorphose within 24 hours if suitable substrate is available, although this can be delayed as much as two weeks (Dean 1965). The recently metamorphosed larvae forms a small tube; maturity is reached in about a month after setting.

There is a decline in number of adults after breeding, unrelated to predation (Vernstein 1979). Brood protection, metamorphosis delay, year-round breeding, and rapid maturity are characteristics of one type of benthic opportunist, according to Grassle and Grassle (1974). The S. benedicti population fluctuates both in space and time in response to changes in environmental conditions, and predation or competition.

Salinity Relationships:

Streblospio benedicti is a euryhaline species, and is found from 5 ‰ (or even less) to full oceanic salinities. It is a characteristic species of the mesohaline and polyhaline Chesapeake Bay.

Other Sensitivities:

S. benedicti builds fragile tubes out of fine sediment and mucous, which lay along the substrate or are buried to a depth of 1 - 2 cm. The species is most abundant in silts and clays, detritus, and similar substrates (Hartman 1945, Dean 1965, Maurer et al. 1978). However, it does occur in sand (Holland et al. 1979).

S. benedicti is eurytopic as regards temperature, and although the peak breeding season occurs when water temperature exceeds $10^{o}C$, some reproduction takes place year round (Virnstein 1979).

The species is very vulnerable to predation, as will be discussed in a following section.

Potential Habitat:

Potential habitat for this species is defined as areas above 5‰ salinity, to 20 m depth; highest abundance in muddy sand, sandy mud, and mud.

Trophic Importance:

Streblospio benedicti is a surface deposit feeder, ingesting detritus, microorganisms, algae, and decaying material. Food is carried to its mouth by the ciliated palps; rejected and fecal material is deposited around the tubes.

S. benedicti is a very small worm, and is fed upon by both larger predators such as fish or crabs, and smaller invertebrates such as shrimp. Caging experiments have shown that extremely high densities can develop in areas free of predators (to 140,000/m^2) (Virnstein 1977, 1979, Holland *et al.* 1979). Virnstein (1979) reported that crab predation was a much more signifant factor than fish predation.

The tubes of this worm serve to stabilize and bind the substrate, allowing colonization by other species such as *Mya* (Virnstein 1979). Biodeposition by this worm also increased the proportion of silts and clays in exclosure cages dense with *S. benedicti* (Virnstein 1979).

Although intra- and interspecific competition generally appear to have little effect on populations of this species (Virnstein 1977, Holland *et al.* 1979), Mills (1967) regards *Ampelisca abdita* as a direct competitor. The two species tend to occupy similar habitats, where the feeding behavior and tubes of the amphipod interfer with the polychaete. Areas with and without *Ampelisca* had significantly different numbers of *Streblospio*.

Selection Factors:

- Abundance, and importance in soft sediment communities, and as a potential colonizer.
- Importance in detrital based food webs, and as prey for various species.
- Importance to substrate stability, biodeposition, and sorting of sediment.

Sources:

Boesch 1971, 1973 unpubl.
Cory and Dresler unpubl.
Dauer *et al*. 1979
Dean 1965
Diaz 1977
Grassle and Grassle 1974
Harman unpubl.
Hartman 1945
Holland *et al*. 1979, 1980
Maurer *et al*. 1978
Mills 1967
Pfitzenmeyer 1975
Reinharz *et al*. unpubl.
Virnstein 1977, 1979

Urosalpinx cinerea - Oyster drill (Map #29)

Description:

Urosalpinx cinerea is a small snail of the family Muricidae. It is about 1.5 - 2.5 cm long, fusiform in shape, with a moderately high-spired shell crossed by numerous rounded folds. The shell is greyish, brown, or yellowish in color, with a white, brown or purple aperture.

Range:

U. cinerea is found from the Maritime provinces to Florida along the western side of the Atlantic. It has also been introduced to (and occurs locally) on the west coast of North America and Great Britain. In Chesapeake Bay the oyster drill is confined to the highest mesohaline and the polyhaline zone. Urosalpinx occurs from the intertidal zone to deep water, limited chiefly by availability of appropriate substrate and prey. It is found most abundantly on pilings, rocks, reefs, and on shells of oyster beds: numbers may rarely reach 200 individuals or more per square meter, but 2 - 20 is a more typical range.

Urosalpinx spawns in the warmer months, from about May through October in Chesapeake Bay. Sexes are separate in this species, and they have internal fertilization. Sperm from a single copulation can remain viable for extended periods (Stauber 1943). About 5 - 20 eggs are laid at a time, enclosed in characteristic whitish to yellow - brown urn-shaped egg capsules about 5 - 10

mm long. Several egg cases may be deposited at once, on hard substrates. The incubation period varies with water temperature, but ranges from 25 - 45 days or more (Carriker 1955). Small protoconches (about 1 mm high) emerge and begin to feed on small bivalves or barnacles. Sexual maturity is reached in about 15 - 25 months, and individuals may live 10 years or more. Because of the non-planktonic larvae and relatively slow rate of reproduction, drills are slow to recolonize areas from which they have been eliminated (by freshets, for example).

Salinity Relationships:

Salinity has a critical influence on the distribution of Urosalpinx. Minimum salinity for survival appears to be near 11‰; and feeding is greatly reduced below 12.5‰ (Manzi 1970). Optimum salinities are about 15 - 35‰ (Carriker 1955). Because of the low mobility of this species, the minimum salinity at any particular spot during the year determines Urosalpinx's presence or absence. Thus in nature, relatively stable "drill lines" existed in the main Bay and tributaries: Towles Point on the Rappahannock, Claybank on the York, Brown Shoals on the James, and Tangier Sound on the eastern shore. After tropical storm Agnes, however, the species was eliminated from much of its range (Andrews 1973), and has not yet recovered (Haven pers. comm.). Low salinities at time of egg-laying have the greatest effect on distribution (Haskin 1974).

Other Sensitivities:

Temperature also has an effect on the distribution of Urosalpinx. Drills become inactive, and may burrow into the bottom, when water temperatures drop below 8 - 10°C. (There is considerable geographic and individual variation in this response). Oviposition begins at around 15°C; although again, there is considerable variation. There is a synergistic effect of temperature and

salinity observed by several investigators: mortality decreases at low salinities when water temperatures are also low (Stauber 1943, Manzi 1970). This enhances Urosalpinx survival during spring months when runoff is highest, and water temperatures still are low.

Urosalpinx is found chiefly on hard substrates, and oviposition can only take place in such areas.

Potential Habitat:

Potential habitat for this species is mapped as areas of former distribution to a depth of 10 m, where suitable substrate exists. The area of present distribution, as well as is known from recent surveys, is also mapped.

Trophic Importance:

Urosalpinx cinerea is a carnivorous snail, and preys upon shelled invertebrates, especially small bivalves and barnacles. Shell of the prey is penetrated by mechanical action of the radula, aided by secretions of the accessory gland, and the flesh of the prey rasped out. Urosalpinx in Chesapeake Bay appears to feed primarily on barnacles, oyster spat, and the smaller stages of other bivalves such as Mya, although it has been shown to prey upon other Urosalpinx, mussels, bryozoans, crabs, and carrion.

Urosalpinx represents one of the principle predators of young oysters and spat. In high salinity areas they can cause serious destruction of planted seed, up to 60 - 70% (Galtsoff 1964).

Selection Criteria:

- Possible range extension resulting from low flow conditions.

- Importance as a predator of small oysters and planted seed.
- Importance of freshets in establishing upstream limits of distribution.

Sources:

Allen 1958

Andrews 1973

Carriker 1955

Galtsoff 1964

Haven *et al*. 1975, 1977, 1979

Lippson 1973

Lippson *et al*. 1979

Manzi 1980

Stauber 1943

Crassostrea virginica - American oyster (Map #30)

Description:

Crassostrea virginica is a large epifaunal bivalve mollusk of the family Ostreidae. Adults range from 75 - 150 mm or more in length, irregularly elongate, with a somewhat cupped lower valve cemented to the substrate. The shape and size of this species varies greatly with growing conditions.

Range:

The American oyster ranges from New England through the Gulf Coast states, in both estuarine and marine waters. It is found attached to a variety of hard substrates (pilings, rocks, oyster shell, firm sand, mud, etc.) in the intertidal to subtidal zones; in many areas extensive reefs or beds are formed. In higher salinity water, predators may eliminate subtidal populations. In Chesapeake Bay, Crassostrea virginica is found from the low mesohaline through the polyhaline zone, primarily in shallow water (less than 8 - 10 meters deep). Densities vary, depending on the type of substrate, from 10 - 100 or more individuals per m^2. Numbers of oysters reaching 1000 or more per m^2 have been recorded in dense intertidal beds along the Gulf coast (Dame 1972).

Oysters spawn during warmer months, when water temperatures are over $15^{\circ}C$. The peak period is typically from mid-July to August (Galtsoff 1964). The exact time of peak spawning and setting can vary from area to area and from year to year, depending on hydro-

graphic conditions. Sperm and eggs are released into the surrounding water, and free-swimming planktonic larvae result. Time to setting of the larvae varies with temperature, and may be as short as 7 - 10 days under optimal conditions. Spat set is highest on clean, sediment-free surfaces, while survival is best in areas with low numbers of predators (such as Urosalpinx, Rhithropanopeus, or Callinectes). Oysters reach harvestable size in 2 - 3 years, and may live 10 years or more.

Crasostrea is limited in higher salinity Chesapeake Bay areas by predators to a certain extent, and by two protozoan parasites, Minchinia nelsoni ("MSX") and Perkinsus marinus ("dermo").

The American oyster is one of the most important and valuable shellfish in Chesapeake Bay and the subject of numerous studies and investigations.

Salinity Relationships:

Crassostrea virginica is an euryhaline species, tolerant of a wide range of salinities from ~ 6 - 7‰ to 35‰. Minimum salinity for survival is 5‰ in the laboratory, although it can withstand lower salinities for short time periods (Castagna and Chanley 1973). Survival is normal at 7.5‰ or higher (Loosanoff 1952). Acclimation may play an important role in response to salinity stress. Chaley (1958) found optimum growth of larvae between 12.5 and 25‰. However, reproduction occurs at different salinities depending upong the acclimation of the adult animals: Davis (1958) found eggs spawned at low salinities (7.5 - 10‰) to develop normally, while eggs from adults held at higher salinities had higher development optima. Lower salinities reduce the range of temperature tolerance for development (Davis and Calabrese 1964). Increase of salinity due to low flow may enhance setting and survival in upstream oyster bars (Kranz, pers. comm.), although new predators may be introduced.

Other Sensitivities:

In its normal estuarine environment, Crassostrea tolerates a wide range of temperatures. Adult oysters can withstand temperatures as low as $1^{O}C$ and in excess of $35^{O}C$. However, below $6 - 7^{O}C$, Crassostrea ceases feeding (Galtsoff 1964). Developmental stages have more restrictive requirements. Gametogenesis is initiated at $15^{O}C$, and peak spawning occurs above $20^{O}C$ in Chesapeake Bay. Normal development of eggs and larvae occurs between $20 - 32^{O}C$, with fastest growth at higher temperatures (Davis and Calabrese 1964). Low salinities narrow this tolerance range.

Oysters are also sensitive to turbidity and sedimentation. Excessive sediment smothers adult oysters and prevents setting of spat. Deposition of sediment within historic times has shifted the upstream limit of oyster distribution downstream several miles (Alford 1968). Areas of good circulation, therefore, are best for oyster setting and survival. Low flow conditions may reduce sediment runoff and deposition in some areas.

Oyster larvae have been shown to utilize the upstream flow of higher salinity water at depth to maintain themselves within the estuary, and to reach upstream oyster beds (Hargis and Wood 1971). In addition, shear zones at frontal areas may be sites of accumulation (and recruitment) of bivalve larvae (Hartwell and Savage 1980). Circulation changes brought about by low flow may reduce the impact of these mechanisms, possibly affecting recruitment.

Like most benthic species, oysters are limited in depth by dissolved oxygen concentrations. In the Chesapeake, most oysters are found in less than 10 meters depth, where circulation is good, distribution may extend to much greater depths (Merrill and Boss 1966).

A major factor affecting density and abundance of oysters in Chesapeake Bay are predation and disease (actually, protozoan parasites). Minchinia nelsoni ("MSX") was introduced to the Bay in the late 1950's - early 1960's, and caused extensive mortality

in higher salinity areas. This sporozoan is most important in salinities over 14 - 15 ‰, and remains a major limit to oysters in these waters. Perkinsus marinus (formerly Dermocystidium or "dermo") occurs into lower salinities than MSX, and is infective during warmer months (when salinities tend to be high). Kranz (pers. comm.) has found active "dermo" infections in oysters at 10 - 11 ‰. Several major predators, in particular the drills Urosalpinx and Eupleura, are also restricted to higher salinities.

Potential Habitat:

Potential habitat for this species is based both on known areas of distribution (oyster ground surveys) and general restrictions of 10 meter depth.

Trophic Importance:

Crassostrea virginica is an epibenthic suspension feeder, ingesting algae, bacteria, and small detrital particles. The majority of particles ingested are in the 1 - 12 μ range, with 1 - 3 μ the largest single size fraction (Haven and Morales - Alamo 1970); this is in the range of nannoplankton and bacteria. An oyster weighing one gram (dry weight) will pump and clear approximately 6 liters per hour, although rate depends on temperature. Particles filtered but not ingested are eliminated as pseudofeces. Fecal and pseudofecal material is important in sediment production and deposition, provides sites for remineralizing bacteria action, and represents a source of food for deposit feeders. In warmer months, an oyster may deposit 1.5 grams or more of feces and pseudofeces per week (Haven and Morales - Alamo 1967).

Oysters are a major commercial species in Chesapeake Bay, and although harvests are reduced compared to historical levels, they still represent a significant economic contribution. Transportation of seed from areas of good recruitment to areas where growth is good and loss to predation and disease reduced is widely

practiced, and in recent years the use of hatcher-produced spat has increased. In the future, oyster culture and harvest will probably become even more managed, with less reliance on natural recruitment.

Selection Factors:

- Sensitivity to circulation freshets, stratification, and sedimentation, all of which could be altered by low flow scenarios.
- Effects of higher-salinity disease and predation.
- Commercial importance.

Sources:

Alford 1968
Andrews 1967
Castagna and Chanley 1972
Chanley 1958
Dame 1972
Davis 1958
Davis & Calabrese 1964
Galtsoff 1964
Hargis and Wood 1971
Hartwell and Savage 1980
Haven & Morales-Alamo 1967, 1970
Haven *et al*. 1977, 1978, 1979
Larsen 1974
Lippson 1973
Lippson *et al*. 1979
Loosanoff 1952
Merrill and Boss 1966
Yates 1913

Macoma balthica - Baltic macoma (Map #31)

Description:

Macoma balthica is a small clam of the family Tellinidae. It is usually less than 3.0 cm in length, with a thin oval shell of white or pinkish exterior and rose-red interior.

Range:

This species is circumboreal in distribution, and is found from the arctic to approximately Georgia on the west coast of the Atlantic. M. balthica is most abundant in estuaries, sheltered bays, and similar brackish environments, and may be replaced in higher salinity areas by the congeneric M. tenta (south of Cape Cod). M. balthica is one of the major mollusks in Chesapeake Bay, and may reach densities of 2000 individuals per m^2 or more although numbers an order of magnitude smaller are more usual. It lives as an infaunal species in muddy sands and softer substrate, and feeds upon detritus. M. balthica exhibits two periods of recruitment each year, corresponding to April - mid June and August - November spawning seasons, a pattern typical of species of boreal affinities.

This species is long-lived and in cold waters may live 10 years or more. Longevity in the Bay is probably half that.

Salinity Relationships:

Macoma balthica can tolerate salinities from 2.5‰ to full oceanic values in the laboratory; however, in nature it is most abundant below 25‰ (Castagna and Chanley 1973). In Chesapeake Bay, *M. balthica* is generally found below 18-19‰. Its distribution may be mediated by competition with *M. tenta* (Boesch 1971).

Other Sensitivities:

M. balthica appears relatively tolerant of sediment type, being found from mud to fine sand, although most abundant in softer substrates. Spawning periods are mediated by water temperature; in Chesapeake Bay the period of spawning corresponds to water temperatures between 15 - 22°C. Like all Chesapeake Bay benthic species, *M. balthica* is sensitive to the typical summer hypoxia in deep waters, and for this reason is generally found in less than 12 - 15 meters depth. However, in areas with good circulation and high dissolved oxygen, it may be found at greater depths.

Potential Habitat:

This sepcies' potential habitat is defined as areas less than 19‰ salinity and less than 12.5 meters deep. Mapping is for fall distribution, after the autumnal recruitment period.

Trophic Importance:

Macoma balthica is an infaunal deposit feeder, ingesting material through use of its long active incurrent siphon. It also ingests a certain percentage of suspended material near the sediment-water interface. Productivity of *M. balthica* is usually highest where bacterial productivity on detrital particles is also high (Tunniclife and Pesk 1977).

Because of its abundance, *M. balthica* is an important source of food for demersal fish, crabs, and waterfowl (Homer and Boynton 1978,

Holland _et al_. 1979). Perry and Uhler (1976) found that _M. balthica_ now represents about 95% of the food of canvasback ducks, probably due to the great reduction in submerged aquatic vegetation in recent years. The great differences in density of _M. balthica_ between caged and uncaged bottom areas (31,000 m^{-2} vs. 733.6 m^{-2} in July) shows the effects of predation on this important species.

Selection Factors:

- Trophic importance as source of food for variety of organisms.
- Potential reduction of range due to increased salinity downstream.

Sources:

Boesch 1971, unpubl.
Castoagna and Chanley 1973
Cory and Dresler, unpubl.
Davies 1972
Diaz 1977
Ecological Analysts 1974
Harman unpubl.
Holland _et al_. 1979, 1980
Homer and Boynton 1978
Johns Hopkins U. 1972
Kaufman _et al_. unpubl.
Lippson _et al_. 1979
Lippson, R.L., unpubl.
McErlean 1964
Perry and Uhler 1976
Pfitzenmeyer 1961, 1970, 1975
Reinnarz _et al_. unpubl.
Tunniclife and Risk 1976

Mercenaria mercenaria - Hard clam, Quahog (Map #32)

Description:

Mercenaria mercenaria is a large bivalve of the family Veneridae. It is about 10 cm or less in length, with oval somewhat arched valves, strong umbones, short siphons, and a wedge-shaped foot. The shell is grey, white, or cream exteriorly, with a white interior and rich purple markings near the posterior and ventral margins.

Range:

The hard clam is abundant near shore from the Gulf of St. Lawrence to the Gulf of Mexico, and in European waters. In Chesapeake Bay it is found in the lower Bay, from the upper mesohaline through the polyhaline zones. Although found in a wide variety of sediment types, Mercenaria is most abundant in firm substrates.

Mercenaria spawns when water temperatures reach 22 - 24°C, and larvae set in the summer months. The species is long-lived, and recruitment to some populations (especially those existing near the lower limits of salinity tolerance) may be infrequent.

Salinity Relationships:

M. mercenaria is a euryhaline marine species and is limited by salinity. Adult clams cannot survive salinities much below 12-12.5‰,

and growth of juveniles ceases below 17.5‰ (Castagna and Chanley 1973). Larvae fail to metamorphose below 17.5‰, and the range of salinity for normal egg development was 20 - 35‰ (Davis 1958).

Other Sensitivities:

Wells (1957) found that the abundance of hard clams was correlated with substrate, and that sediment preference followed this order: shell, sand, sand/mud, mud. Abundance in shell may be related to larval setting behavior, as the larvae prefer to attach their byssus to a firm substrate lightly covered by sediment.

Temperature also affects this species. The minimum temperature necessary for spawning (22 - 24°C) may limit Mercenaria in the northern part of its range. Davis and Calabrese (1964) found the optimum temperature for growth of clam larvae was 25 - 30°C.

Freshets occurring during spawning periods could affect larvae both through direct salinity stress and by flushing them from the estuary.

Potential Habitat:

Potential habitat for this species is defined as areas in greater than 12 ‰ salinity, in depths between 1 - 10 meters. Highest abundance is in sand and muddy sand. The species is mapped in its summer distribution pattern.

Trophic Importance:

Mercenaria mercenaria is a shallow-burrowing infaunal suspension feeder, ingesting detritus and phytoplankton. In turn, it is food for a number of fish, crabs, and waterfowl, although the large size and solid shell of the fully adult clam afford it a measure of protection. Gulls and rays feed upon the adult clams, the former

dropping them from height to crack the shell; the latter relying on their powerful dental pavement to crush the clam (Hibbert 1977, Orth 1975). Juveniles and newly set spat are preyed upon by crabs, demersal fish, and waterfowl.

The hard clam is also a commercially important species, although harvests in the Bay are limited by irregular recruitment (itself due to low salinities). Areas which support harvests include the lower York River, Tangier and Pocomoke Sounds. Transfer of young clams from areas of good recruitment (or from hatcheries) to regions suitable for growth has potential to increase the fishery. Higher salinities resulting from low flow might produce a larger and more stable population of *M. mercenaria* in the Bay, although increase of certain predators such as *Busycon* could also result.

Selection Factors:

- Distribution limited upestuary by salinity and potential for range increase due to low flow.
- Narrow salinity tolerance of larvae, and sensitivity to freshets.
- Commercial importance, and potential for fishery increase.

Sources:

Allen 1954
Boesch *et al*. 1973
Castagna and Chanley 1973
Davis 1958
Davis and Calabrese 1964
Haven *et al*. 1975, 1977, 1979
Hibbert 1977
Lippson 1973
Orth 1975
Pfitzenmeyer 1961
Wells 1957

Mulinia lateralis - Coot clam (Map #33)

Description:

Mulinia lateralis is a small clam of the family Mactridae. It is approximately 2.0 cm in length, wedge-shaped, with arched valves, white in color.

Range:

Mulinia lateralis is found nearshore in estuaries, bays, and shallow areas from Canada to the eastern Gulf of Mexico. In Chesapeake Bay it is most abundant in shallow, nearshore environments in the upper mesohaline and polyhaline zones, in a variety of sediment types. Abundance of Mulinia varies greatly from year to year and place to place; it is a fugitive, eruptive species with an opportunistic life history. Densities may reach 5000 m^{-2} or more, but 200-600 individuals per m^2 are far more common. Typical of opportunistic forms, it is short-lived, usually less than one year, and there may be 2 - 3 generations a year in Chesapeake Bay (Boesch et al. 1973). M. lateralis grows quickly, and can reach 13 mm length and be sexually mature in two months or less from setting (Virnstein 1979). Predation plays an extremely important role in the distribution and abundance of this species (Virnstein 1977).

Mulinia recruitment is at a maximum in late fall and early spring, and the species typically suffers heavy summer mortalities due to predation, turbidity, anoxia, or competition. M. lateralis begins

spawning in spring when temperatures reach 15°C, usually mid-May, and continues until mid-November in Chesapeake Bay.

Salinity Relationships:

In the laboratory, *M. lateralis* can survive salinities down to 2.5 but 100% survival of adults occurs only above 10‰ (Castagna and Chanley 1973). It tolerates full oceanic salinities as well. In nature, the species is not found below about 10‰. This probably reflects the greater salinity sensitivity of the embryos and larva Calabrese (1969) found optimum salinity for embryos to be 20 - 27.5 and for larvae, 20 - 30‰, with no development occurring below 15‰. Spawning cannot occur below 7.5‰ (Castagna and Chanley 1973).

During the mid-1960's drought, *M. lateralis* extended its range upestuary to the mouth of Romney Creek.

Other Sensitivities:

M. lateralis occurs in a wide variety of sediment types, but is somewhat more abundant in muddy sand and mud. Like many infaunal benthic species in Chesapeake Bay, it can be limited by summer anoxia in deep water. In addition, high turbidity near the sedime water interface can be limiting to this suspension feeder (Boesch *et al*. 1976).

Temperature affects *M. lateralis* primarily through its effect on spawning and development. The LC_{50} for temperature for adult *Mulinia* is approximately 30 - 33°C, which can be approached in nearshore areas in summer. The optimum temperature range for embryos is 15 - 20°C, and for larvae, 20 - 30°C (Calabrese 1969).

Potential Habitats:

Potential habitat for this species is defined as areas in greater than 10‰ salinity, depths less than 12.5 meters. Mapping is done for late fall and winter, a period of maximum distribution due to higher salinities and fall recruitment.

Trophic Importance:

M. lateralis is an infaunal suspension feeder, ingesting fine particles, bacteria, phytoplankton, and microzooplankton near the sediment/water interface. The major importance of *Mulinia* is as prey for numerous species of fish, crabs, and watefowl. Virnstein (1977, 1979) found both spot and crabs to feed on *Mulinia*, and to have severe effects on density; numbers in exclosures may reach 8000 m^{-2} or more, versus trace populations in cages subject to crab predation. Heavy predation on this species in warmer months may reduce summer populations to small reservoirs in shallow nearshore areas (Wass *et al*. 1972).

Selection Factors:

- Trophic importance for demersal fish and crabs, as well as productivity and turn-over time.
- Potential for range extension upestuary if salinities increase due to low flow.
- Sensitivity to turbidity and anoxia, both affected by flow regimes.

Sources:

Boesch 1971, 1973 unpubl.
Boesch *et al*. 1973, 1976
Calabrese 1969
Castagna and Chanley 1973
Cory and Dresler unpubl.
Holland *et al*. 1979, 1980
Lippson, R.L. unpubl.
Pfitzenmeyer 1970, 1975
Reinharz et al. unpubl.
Virnstein 1977, 1979

Sources (cont.

Diaz 1977
Harman, unpubl.
Wass *et al*. 1972

Mya arenaria - Soft clam (Map #34)

Description:

Mya arenaria, the soft-shell clam or mannose, is a relatively large bivalve, belonging to the family Myacidae. It is a relatively elongate oval form, with gaping valves, large fused siphons, the shell dull white in color. Adult Mya inhabit permanent burrows in shallow water.

Range:

M. arenaria is found from Labrador to approximately Cape Hatteras on the east coast of North America and also is found in European waters. In northern latitudes it is more often found in areas at or near full oceanic salinities, whereas at the southern part of its range it is primarily an estuarine inhabitat (Pfitzenmeyer 1965). In Chesapeake Bay, Mya is found in shallow intertidal and subtidal areas in a variety of substrates, from the oligohaline through the polyhaline zones. Abundance varies widely: numbers may reach 1000 m^{-2} or more, but generally are less than 200 per m^2. M. arenaria is commercially harvested in Chesapeake Bay, often by use of the hydraulic escalator dredge which can reach the subtidal populations.

Mya exhibits the bimodal spawning pattern typical of mean boreal species in Chesapeake Bay. Spawning starts in May and continues through June, ceases during the warmest months, resumes in late August and continues until November. Recruitment (setting) occurs in both late spring and fall, but the spring recruitment is often unsuccessful. This is probably due to predation on the young clams,

particularly by blue crabs. Mya arenaria is a long-lived species, and may reach 10 years or more in age. Recruitment into many populations may occur at widely-spaced intervals (Haven 1976).

Salinity Relationships:

In the laboratory, M. arenaria has been able to survive salinities as low as 2.5 ‰ indefinitely. In nature, however, it is generally found above 3 - 3.5 ‰, and not numerous until salinities are above 5 ‰. Greatest abundance occurs in water over 8 ‰, which may reflect the observed minimum for larval survival, 8 ‰ (Castagna and Chanley 1973). It occurs in Eastern shore bays at salinities of 35 ‰ or so, but not at high densities.

M. arenaria is also sensitive to freshets which not only can kill adult clams upestuary, but can eliminate larvae from tributaries by flushing or by salinity stress. After Tropical Storm Agnes, soft clams were eliminated over much of the Bay. A successful spawning in fall restored numbers to a great extent baywide.

Other Sensitivies:

Mya is tolerant of a wide variety of substrates from sand to mud and peat, but unstable substrates support lowest densities. Adult Mya live in permanent burrows, and are slow reburrowers, thus vulnerable to sediment disturbance by waves, currents, or bioturbation. They are also quite susceptable to anoxia in deeper regions in summer; young clams may recruit into deep water in spring, but suffer high mortalities during warm months (Boesch, unpubl.). Adult clams are thus most abundant in stable substrates less than 6 - 10 meters depth. Because of the low tidal amplitude in Chesapeake Bay, most of these are subtidal.

Temperature also affects Mya arenaria: spawning occurs mostly between 15 and 22°C; unspawned gametes are resorbed in warmer waters,

and the clam's gonads are inactive until temperatures drop in early fall (Pfitzenmeyer 1962, 1965). The lethal temperature for Mya arenaria is 32.5°C (adults), which can limit intertidal distribution in the southern part of the species range (Kennedy and Mihursky 1971).

Potential Habitat:

Potential habitat for this species is defined as areas greater than 3.5 ‰ and shallower than 10 meters. The species distribution is mapped in spring.

Trophic Importance:

Mya arenaria is an infaunal suspension feeder, ingesting small detrital particles, phytoplankton, bacteria, and microzooplankton through its long extensable siphon. Adult clams burrow deeply, while juveniles live closer to the surface and are more vulnerable to predation (Virnstein 1979).

Mya represents a major prey organism for numerous fish, crabs, and waterfowl when it is abundant. It is a favored prey of the blue crab (and green crab, Carcinus maenas, in northern waters) and these organisms are major factors controlling Mya's abundance. Set of spat into predator exclusion cages can be exceedingly heavy: Virnstein (1979) counted in excess of 65,000 per m^2, while areas outside the exclosure had only trace populations.

Commercial harvesting can also reduce populations, both through direct harvest and by disruption of sediment and removal of sub-adult from their burrows (making them vulnerable to predation during the relatively long reburrowing process).

Selection Factors:

- Trophic importance to fish and crabs.
- Commercial importance of species.
- Potential upstream expansion of range under low flow conditions, due to salinity increase, and reduction of freshets and turbidity.

Sources:

Boesch 1973, unpubl.
Castagna and Chanley 1973
Cory and Dresler unpubl.
Diaz 1977
Ecological Analysts 1974
Harman unpubl.
Haven 1976
Holland et al. 1979, 1980
Kaufman et al. unpubl.
Kennedy and Mihursky 1971
Lippson, R.L. unpubl.
Pfitzenmeyer 1961, 1962, 1965, 1970, 1975
Virnstein 1979

Rangia cuneata - Brackish-Water Clam (Map #35)

Description:

Rangia cuneata is a medium-sized clam of the family Mactridae. It is about 3.5 cm (maximum 7.0 cm) in length, wedge-shaped, with arched valves, white in color with a dark periostracum. Rangiais not native to Chesapeake Bay, but was introduced there around 1960.

Range:

R. cuneata was found from New Jersey to Mexico during the Pleistocene, but in the Recent period was restricted to the Gulf coast. However, it has extended its distribution within the last 25 years to include east coast waters from Florida to Delaware Bay (Hopkins and Andrews 1970, Maurer et al. 1974), essentially reoccupying its old range. The clam was probably carried in seed oysters from the Gulf of Mexico to the east coast. In Chesapeake Bay, Rangia was first discovered in 1960 in the James River, and by 1968 was found in the upper Bay (Gallagher and Wells 1969). It is restricted to the tidal freshwater, oligohaline, and low mesohaline zones of the Bay mainstem and most tributaries, except the York River. Populations are variable in numbers and range, due both to year-to-year differences in recruitment and to winter mortalities caused by low temperatures and ice scour. Densities may reach 5000 clams or more per m^2 in favorable areas, but numbers an order of magnitude smaller are more typical.

Rangia may spawn in early summer (a minor peak), but the major period of reproduction begins in autumn and continues to early winter (Cain 1975). Spawning is highly correlated to ambient salinity and temperature, and ripe clams need certain salinity stimuli to initiate spawning. The fall and winter recruitment of larvae is usually most successful. R. cuneata is long-lived (up to 10 years), and reaches sexual maturity at about one year of age (Cain 1975). Because of the spawning requirements and salinity sensitivity of the larvae, recruitment to some areas may be sporadic, and the Rangia population consist entirely of individuals of one or two year classes.

Salinity Relationships:

Rangia cuneata is an estuarine endemic, extremely eurytopic as to salinity as an adult. In the laboratory, Rangia could survive freshwater, and after acclimation, 30 ‰ indefinitely. In nature, however, adult clams are found mostly below 10‰, extending nearly to (or into) tidal freshwater.

The explanation for this range restriction appears due to the reproductive physiology of the organism. Ripe Rangia require some stimulus of salinity or temperature change to induce release of gametes. Cain (1975) found that a change in salinity up from 0‰ or down from 10‰ or 15‰ to be necessary, with a change from near 0‰ to 5‰ best. Early larvae require salinities from 2 - 10‰ to develop, although older larvae are more tolerant, surviving up to 20‰ (Hopkins et al. 1973). After setting, salinity per se has little effect on Rangia.

Other Sensitivities:

In Chesapeake Bay, R. cuneata is near the northern limit of its range. For this reason, temperature can play an important role

in the distribution and survival of the organism. Prolonged temperature at or near $0^{\circ}C$ can cause massive mortalities; in addition, clams in the shallowest subtidal regions can be seriously affected by ice scour. The severe winter of 1976-1977 eliminated *Rangia* from much of its range within Chesapeake Bay, and the species has not yet fully recovered.

Temperature also controls reproduction: gametogenesis occurs between $10-16^{\circ}C$, and spawning between $12-22^{\circ}C$ (however, dependent on salinity stimulus). Larval survival is best at $24^{\circ}C$, and growth slows or stops below $16^{\circ}C$ (Cain 1975).

Rangia cuneata is found in a variety of substrates from fine sand to mud. Several investigators have found specimens in sand to have better survival and growth than individuals in mud (Tenore *et al*. 1968, Peddicord 1977). This may be due to higher suspended solids in waters immediately over mud sediments, which reduces pumping rate and increases pseudofeces production (Peddicord 1977).

Depth *per se* does not affect *Rangia* but summer anoxia below 10 meters (particularly in the turbid oligohaline transition region) limits its distribution. Ice scouring and winter cold impacts populations in very shallow water, and most clams are found in 1 meter depth or more.

Potential Habitat:

Potential habitat for this species is defined as areas less than 10‰ to about 0.1‰ salinity, between 1 and 10 meters depth. The species is mapped in summer, the time spawning is initiated.

Trophic Importance:

Rangia is an infaunal suspension feeder, ingesting detritus, phytoplankton, and bacteria. It has also been shown to take up amino acids from the ambient medium (Hopkins *et al*. 1973).

This species is of particular interest because it is a new addition to the Bay fauna, and occurs in the oligohaline zone where benthic faunal diversity is lowest (Diaz 1977). Its biomass and wide distribution indicate that it might represent a new food source for fish, crabs, and waterfowl. Waterfowl have been shown to utilize the smaller sized clams, although the larger individuals are difficult to crack to extract meat (Perry and Uhler 1976). Mammals also use this clam as food; raccoons have been observed digging the clams at low tide in shallow water, and opening them with their teeth. In all, Hopkins (1973) lists 20 or more species which feed on Rangia throughout its range; many of these are important in Chesapeake Bay.

Rangia also has commercial importance, not yet exploited in Chesapeake Bay. On the Gulf Coast its shells are used for road material (hence its common name, Southern Road Clam), and the meats packed and sold for food. Many people harvest this species in a non-commercial basis, but the small size of Rangia in the Bay region reduces its potential as a commercial species.

Selection Factors:

- Sensitivity of reproductive cycle to salinity changes, and restricted tolerance of larvae.
- Trophic importance, and biomass dominance in many oligohaline areas.
- Potential decrease of range due to low flow.
- Potential commercial importance.

Sources:

Boesch 1972
Cain 1975
Castagna and Chanley 1973
Hopkins and Andrews 1970
Hopkins et al. 1973
Johns Hopkins U. 1972

Sources (cont.):

Cory and Dresler, unpubl.
Davies 1972
Diaz 1977
Ecological Analysts 1974
Gallagher and Wells 1969
Harman, unpubl.
Holland et al. 1979, 1980
Lippson, 1973
Lippson et al. 1979
Maurer et al. 1979
Peddicord 1977
Perry and Uhler 1976
Pfitzenmeyer 1968, 1970, 1975
Tenore et al. 1968

Ampelisca abdita - Amphipod (Map #36)

Description:

Ampelisca abdita is a burrowing amphipod of the family Ampeliscidae. The body is of generally typical amphipod shape, about 5 - 8 mm in length, with females somewhat smaller. The antennae and peraeopods are modified for feeding. This is a fairly recently described species (Mills 1964), and in many earlier collections it was confused with its sibling species A. vadorum or other congenerics.

Range:

A. abdita is found from the boreal region of Maine at least to the western Gulf coast, excepting southern Florida. In Chesapeake Bay, it is found in the high mesohaline through the polyhaline zones. Densities typically are less than 2000 per square meter, but accumulations of 30,000/m^2 or more have been recorded. Mills (1967) characterizes this species as successful in crowded conditions because it grows rapidly, and breeds early.

Ampelisca abdita inhabits a tube for the greater portion of its life, save for a brief free-swimming period during reproduction. The tube is construced of fine sand grains glued together with a secretion from the first two pairs of pereiopods, which hardens to a parchment-like material. The tube is about 3 - 4 cm long,

flattened laterally, and rather flexible.

Reproduction is linked to water temperature, and 8 - 10°C seems to be the initiating temperature. Overwintering animals reaching sexual maturity in spring leave their tubes and swim about, particularly at times of spring tides and full moon. Mature males grasp mature females and carry them about; the female then molts and copulation occurs. Mature males die soon after mating, but females return to the substrate to brood their eggs. Females produce only one brood in their lifetime. Young animals disperse and build small tubes. They grow rapidly, building larger and larger tubes, and reach sexual maturity by mid-summer. Their offspring overwinter, growing more slowly, and breed the following spring.

Salinity Relationships:

There are apparently no laboratory studies delineating the exact physiological salinity tolerances of *A. abdita*. However, field collections in Chesapeake Bay indicate that the species is confined generally to areas above 12‰ (e.g. Boesch 1971, unpubl., Wass 1972).

Other Sensitivities:

Temperature affects *A. abdita* in regard to both growth rate and reproduction. As previously mentioned, 10°C appears to be the initiating temperature for reproduction. South of Cape Hatteras, where winter temperatures remain high, breeding occurs throughout the year (Mills 1967). Growth, however, can occur in temperatures as low as 3 - 4°C. Thus overwintering individuals may attain much greater size than summer broods.

The distribution of *A. abdita* is influenced by sediment type. In general, it is most numerous in fine sediments, including fine

sand, silts, and clays. It's sibling species, A. vadorum, is considerably larger and better adapted to coarse substrates (Mills 1967, Watling and Maurer 1972). The two species may occur together, but generally densities are then low, suggesting competition (Mills 1967).

A. abdita has been recorded from the intertidal to depth, in Chesapeake Bay; however, it appears to occur primarily subtidally This probably reflects sediment preferences. Feeley and Wass (1967) record it as the most numerous ampeliscid in lower Chesapeake Bay. It occurs seasonally in submerged aquatic vegetation beds, primarily during reproductive periods (Marsh 1970, Orth 1973).

Potential Habitat:

Potential habitat for this species is defined as areas above 12‰ salinity, from 3 - 15 m in depth, most abundant in muddy sands, sandy mud, and mud.

Trophic Importance:

A. abdita is considered a suspension feeder, ingesting suspended detritus, algae, and algae attached to sand grains, although it also resuspends sediment from the bottom, and thus ingests deposited material. The animal feeds at the top of its tube, ventral surface uppermost. The pleopods and second antennae beat and whirl rapidly, setting up feeding currents over the mouth parts.

A. abdita is in turn fed upon by various birds, fish, and other predators. It is sometimes extremely dense, and its tubes constitute a major feature of its habitat. The tubes not only help bind the substrate, they provide shelter and attachment for numerous other species. Mills (1967) noted that fine sediments accumulated around the tubes, providing food for deposit feeding

species. In addition, the animal's activity keeps the sediment oxygenated to the depth of the tube. Chlorophyll values were also about two times greater than in a nearby tubeless area (Mills 1967).

Selection Factors:

- Potential for range increase under low flow conditions.
- Abundance, and importance in binding soft sediments, providing shelter for other species, and oygenation of substrate.

Sources:

Boesch 1971, 1972, 1973, 1977, unpubl.
Bousfield 1972
Diaz 1977
Feeley 1967
Marsh 1970
Mills 1964, 1967
Orth 1973
Reinharz et al. unpubl.
Watling and Maurer 1972
Wass et al. 1972

Balanus improvisus - Acorn barnacle (Map #37)

Description:

Balanus improvisus is a small barnacle of the family Balanidae. It is about 0.5 to 1.5 cm in diameter; its shell a low cone formed of six overlapping somewhat triangular plates, and the shell orifice closed by four triangular opercular valve plates.

Range:

Balanus improvisus is common in the low intertidal and subtidal zones, primarily in lower salinity water, in temperate and subtropical areas worldwide. In Chesapeake Bay it is most abundant in the oligohaline and low mesohaline areas, but can occur into the polyhaline zone. Densities can reach 50,000 individuals per m^2 or more under favorable conditions.

Acorn barnacles exhibit two periods of setting in many Chesapeake Bay areas. Calder and Brehmer (1967) found a heavy set at Hampton Roads in May, with another recruitment in October. However, Branscomb (1976) reports only a spring set in 1972, the year of Tropical Storm Agnes.

Barnacles are hermaphroditic, but cross-fertilization is the rule. B. improvisus spawns in spring and fall in Chesapeake Bay. The eggs are brooded in the mantle cavity, and the larvae released as nauplii which have a characteristic horned, triangular cara-

pace. The nauplii metamorphose into the bivalve cyprid larvae, which seek out and attach themselves to hard substrates by a short stalk. Further metamorphosis occurs, to produce the typical adult shape. Barnacles reach adult size in approximately four to six months, depending on water temperature, availability of food, and crowding effects. There is often heavy mortality due to predation, spatial competition, and in winter, effects of cold and dessication (Branscomb 1976).

Barnacles are principle fouling organisms in marine areas. _B. improvsis_, one of the dominant species in Chesapeake Bay, is important in bio-fouling of ships, pilings and other structures, water intake and condensor tubes, as well as oyster beds. For this reason, considerable effort has been devoted to study and control of barnacles and other fouling species.

Salinity Relationships:

B. improvisus is a relatively eurytopic species in respect to salinity. It occurs in nature in salinities as low as 2‰, and up to 20 to 24‰ (Gordon 1969). Turpaeva and Simkina (1961) found optimum growth of this species in the Black Sea occurred at 5 to 11‰, which corresponds generally to its major abundance in Chesapeake Bay. It is able to withstand lower salinities for short periods, as Larsen (1974) reported it year round at a station where salinities dropped in spring to 0.7‰.

B. improvisus is, however, seriously impacted by predators — some of which are limited to higher salinities. The flatworm _Stylochus ellipticus_ is a major cause of summer barnacle mortality (Branscomb 1976); it is rarely found below 9 - 10‰ in nature (Larsen 1974). In the laboratory, Landers and Rhodes (1970) found _Stylochus_ to be able to survive and feed at salinities of 5‰ or above, so the apparent salinity limit of its realized range may reflect reproductive stress.

Other Sensitivities:

B. improvisus are sensitive to low winter temperatures, particularly when in conjunction with high winds. The combination of these two factors accounts for a major part of intertidal barnacle mortality in Chesapeake Bay (Branscomb 1976). Recolonization of the intertidal apparently results from surviving subtidal populations.

In addition to predators such as *Stylochus*, *Urosalpinx*, and crabs, barnacles are affected by competition for space. The bryozoan *Victorella pavida* is a major spatial competitor, smothering the barnacles (Branscomb 1976).

Balanus is restricted to hard substrates, and occurs on rocks, pilings, bivalve and crustacean shells, and so forth. Anoxia in summer may reduce or eliminate individuals in depths greater than 10 m, although the species can be found to 15 m or so.

Potential Habitat:

Potential habitat for this species is defined as areas between 2 - 24‰, to 15 m, when hard substrate exists. Over 10‰, the species is reduced by predation.

Trophic Importance:

B. improvisus is an epibenthic suspension feeder, and ingests bacteria detritus, algae, and small zooplankters. They are capable of selective feeding, and show a preference for animal food (Kuznetson 1972, 1979). They may also ingest the larvae of invertebrates, including barnacle nauplii.

Barnacle nauplii may constitute a significant portion of the zooplankton at some times of the year or in certain areas (Herman

et al. 1968). At such times they can become a source of food for planktivorous fish, larvae, and suspension feeding invertebrates.

Selection Criteria:

- Sensitivity to predation, in higher salinities.
- Biomass and economic importance as a fouling organism.

Sources:

Branscomb 1976
Calder and Brehmer 1967
Diaz 1977
Gordon 1969
Harman unpubl.
Herman et al. 1968
Kuznetsova1972, 1979
Landers and Rhodes 1970
Larsen 1974
Lippson et al. 1979
Lippson, R.L. unpubl.
Turpaeva and Simkina 1961

Callinectes sapidus - Blue crab (Map #38, 39)

Description:

Callinectes sapidus is a swimming crab of the family Portunidae. Adult crabs are 120 mm or larger across the body (point to point), and have the last pair of walking legs expanded and flattened for use in swimming. Males ("jimmies") are typically larger than females, have larger claws, and a T-shaped abdomenal apron, while that of the mature female ("sook") is broadly rounded. The general body color is bluish green or brownish-green, with a white underside, bright blue markings on the first pair of legs, and in the female, red tips on the claws. This is one of the most important commercial and recreational species in Chesapeake Bay.

Range:

Blue crabs are found inshore from New England to Mexico, and have recently colonized the Mediterranean Sea (probably transported in water ballast). In Chesapeake Bay, they are found from freshwater to the Bay mouth, but there are distinct differences in the ranges of males and females. In summer, adult males range from freshwater into the polyhaline zone, with maximum concentrations from about 3‰ to 15‰. Females are found in maximum numbers from 10‰ to the Bay mouth, reflecting their orientation to the high salinity spawning areas. Where the two sexes overlap in abundance delineates the major areas of mating, which in the mainstem occupies Tangier Sound and the lower portion of the

Maryland Bay. Mating occurs in summer, and is at a peak in August and early September. A male locates a suitable mate, "cradle-carries" her until she molts, and then mates while she is in the soft crab stage. After her shell hardens, she is released and begins her migration to the spawning grounds at the Bay mouth. Eggs may be laid in late summer, or the sperm stored and used in the next year. Sponge crabs (females carrying eggs) are first seen in late May. Zoea are released in water over 25‰ salinity in the lower Bay or on the shelf, usually nearshore. The zoea tend to be carried out of the Bay in surface waters. After metamorphosis to megalops, the young crab settles towards the bottom, and can be transported back into the Bay by bottom currents.

Newly metamorphosed true crabs begin their up-Bay migration in about August, which (interrupted by winter) can continue until the next spring. Adult size is reached one to one and a half years after hatching.

In colder months, the crabs leave the shallow inshore areas, and seek depths greater than 10 - 15 meters. There they bury in the sediments to overwinter in a state of semihibernation. Most of the females are, by that time, in the lower Bay; this concentration of overwintering females supports a winter dredge fishery in Virginia.

Salinity Relationships:

Physiologically, adult crabs can tolerate salinities from freshwater to oceanic levels (Tagatz 1971). The observed differences in range of males and females reflects for the most part life history and breeding requirements. This spatial separation of the sexes apparently occurs at an early stage (Miller et al. 1975).

The spawning and development stages are, however, restricted by salinity. Spawning success is greatest and zoeal survival best at salinities between 23 - 30‰. If salinities are below about 18‰, eggs hatch in the abnormal "prezoea" stage, which dies. Optimal salinity range for development is about 21 - 28‰. The megalops is somewhat more tolerant of salinity, although the optimum range is between 20 - 35‰ at 20 - 25°C (Costlow 1967). Higher salinities and lower temperatures delay metamorphosis to the crab stage, which has implications for the offshore transport of megalops between estuaries.

Other Sensitivities:

Blue crabs are affected by temperature, both as adults and as larvae. The range of temperature necessary for hatching is 19 - 29°C. Temperatures above 20°C produce the most rapid development of the megalops; below this, development is delayed by a factor of 2 to 4 times.

Adult crabs are more active in warm water, and in fall as temperatures fall below 10°C, they move to deeper water to overwinter. Lower temperatures affects the crabs' ability to osmoregulate, and may prompt this migration (Amende 1974).

Because of the blue crab's life history, maintenance of the species within the estuary depends upon the two-layered circulation pattern typical of Chesapeake Bay. As the megalops metamorphose over the continental shelf, they migrate towards the bottom, and re-enter the Bay in bottom currents. The northward-flowing deep water assists the upestuary migration of the newly developed true crabs, as well. In addition, freshets tend to carry zoea out over the shelf, reducing the chance that the megalops will return into Chesapeake Bay (Van Engel, pers. comm.). Both circulation and freshets will be affected by low flow conditions.

Potent.al Habitat:

The species is mapped at two seasons, because of its widely different winter and summer distributions. Potential habitat in summer for males are areas from the head of tide to approximately 15‰, while that of females is from 10‰ to the Bay mouth. Spawning areas are nearshore waters where salinities exceed 25‰. Potential habitat in winter for males are regions deeper than 12.5 meters, over 5‰ salinity to about 20‰; for females it is areas deeper than 30 feet in the lower Bay.

Trophic Importance:

Callinectes is an active swimming and crawling scavenger and predator. The zoea prey upon zooplankton, and adults are major predators of benthic organisms. Crabs can dig and crack the shells of mollusks such as Macoma, Mulinia, Mya, Rangia and Mercenaria, as well as feeding upong oyster spat and young oysters. They are important predators on numerous polychaete worms, as well, such as Streblospio, Nereis, and Polydora (Virnstein 1977, 1979). Only deep or rapidly burrowing forms can escape this active animal. Callinectes is probably a major factor controlling populations of many benthic invertebrates (Virnstein 1979). Other food includes roots and stems of seaweeds and SAV, including Zostera, smaller crustacea, and fish (Van Engel 1958, Tagatz 1968). Blue crabs are occasionally destructive to newly set oysters or clam.

The blue crab is itself used as food by a large number of species including man. Many fish, such as the striped bass, feed upon young crabs, as do waterfowl and mammals such as raccoons. The species is one of the most important commercial and recreational organisms in Chesapeake Bay. About 50,000,000 pounds are harvested annually by commercial crabbers, and the sports fishery is probably equally large. Thus any effect on this species resulting from low flow would have wide repercussions both environmentally and economically.

Selection Factors:

- Trophic importance, particularly as a predator on benthic invertebrates.
- Sensitivity of reproduction to salinity, circulation, and freshets.
- Major commercial and recreational importance

Sources:

Amende 1974
Costlow 1967
Graham and Beaven 1942
Holland _et al_. 1979, 1980
Lippson 1973
Lippson _et al_. 1979
Lippson, R.L. 1971, unpubl.
Miller _et al_. 1975
Miller _et al_. 1975
Pearson 1948
Sandifer 1973, 1975
Sandoz and Rogers 1944
Tagaty 1968, 1971
Van Engel 1958
Virnstein 1977, 1979

Cyathura polita - Isopod (Map #40)

Description:

Cyathura polita is a moderate sized isopod of the family Anthuridae. It is about 12 - 20 cm in length, with a narrow elongate body, the first pair of legs subchelate and are modified for grasping, the other six pairs similar and used for walking and burrowing. Color varies with substrate, but is typically greyish-brown.

Range:

C. polita is found along the Atlantic and Gulf coasts, chiefly in estuarine waters, from Maine to Louisiana. In Chesapeake Bay it is found from oligohaline to mid-mesohaline areas, although in other parts of its range it has been found under hypersaline conditions (Burbanck 1967). The species builds tubes in stable substrates. Numbers may reach $1000/m^2$ or more under favorable conditions, although less than $500/m^2$ is a more typical density.

C. polita broods its young in a marsupium, and fertilization is internal. Gravid females are found only in warmer months in the northern part of the species' range, while reproduction is year-round in subtropical areas (Burbanck 1967). Juvenile animals live interstitially in the substrate. Animals are believed to live about three years. There is evidence that protogynic hermaphrodism is common in C. polita; that is, the animal functions as a female its second year, and a male in the third (Burbanck and Burbanck 1974). In Florida, Kruczynski and Subrahmanyam (1978)

found juveniles maturing sexually in one year, and living only two years. Cyathura do not range widely, and most individuals spend their life within a few square meter's area.

Salinity Relationships:

C. polita adults are found in a wide range of salinity from fresh or near fresh water, to full salinity, and even (for part of the year) hypersaline conditions. In the northern part of its range, it is more common at full salinity. However, in Chesapeake Bay, the species occurs mainly below 12 ‰. Laboratory experiments have shown adults can survive a range of 0 - 40‰ or more for several hours (Kelley and Burbanck 1972).

In the laboratory, embryos of C. polita develop normally only between 0.5 - 20‰, while at 30‰, larvae develop normally but embryos die (Kelley and Burbanck 1976). The distribution of this species thus probably reflects the sensitivity of the embryo. However, competition or predation may also affect the species' occurrence in Chesapeake Bay.

Other Sensitivities:

C. polita constructs tubes in stable substrates to a depth of 7 cm or so. It is most numerous in sand, shell, firm clays, and silty sand sediments; less numerous or absent in soft muds (Kruczynski and Subrahmanyam 1978). The species is sensitive to low dissolved oxygen, which further limits its distribution in unstable muds and in deep water (Burbanck 1967). C. polita is found in salt marshes, intertidally, and subtidally to depth, until restricted by summer anoxia or hypoxia.

Adult C. polita are tolerant of a wide range of temperatures, reflected in their boreal-subtropical distribution. Reproduction, however, occurs in warmer months, generally April - August in most of its range. There is evidence that extremes of temperature

limit osmoregulatory ability, and that this is most pronounced in southern populations (Burbanck 1967).

Potential Habitat:

Potential habitat for this species is defined as areas between 0.5 - 12‰ salinity, with highest densities occurring between 1 and 7‰, in sand, muddy sand, and sandy mud, down to approximately 6 meters depth.

Trophic Importance:

Cyathura polita is an omnivorous feeder, ingesting detritus, algae, dead animal matter, and small organisms. Since in some habitats it represents the most numerous benthic species, it probably contributes significantly to transfer of material and energy from detritus to other food webs. *C. polita* has been shown to be used as food by numerous species of fish throughout its range (Burbanck 1963), and it is probably also preyed upon by crabs. Predation by fish has been cited as one cause of the species summer decline in many areas (Burbanck 1967).

Holland *et al*. (1980) found *C. polita* populations to increase inside predator exclusion cages during summer months. *C. polita* appeared as an important item in the diet of juvenile weakfish and other bottom feeding species collected near Calvert Cliffs, although the isopod is not an abundant member of the benthos there (Homer and Boynton 1978, Holland *et al*. 1979).

Selection Factors:

- Abundance in oligohaline areas, where the major effects of low flow are expected.
- Importance to detrital food web and as food for fish.
- Sensitivity of embryonic stages to higher salinites.

Sources:

Boesch 1971
Boesch et al. 1976
Burbanck 1963, 1967
Burbanck and Burbanck 1974
Cory and Dresler unpubl.
Diaz 1977
Harman unpubl.
Holland et al. 1979, 1980
Homer and Boynton 1978
Kelley and Burbanck 1972, 1976
Krucynski and Subrahmanyam 1978
Lippson, R.L. unpubl.
Pfitzenmeyer 1970, 1975
Reinharz et al. unpubl.

Gammarus daiberi - Amphipod (Map #41)

Description:

Gammarus daiberi is a small epibenthic amphipod of the family Gammaridae. It is about 6 - 12 mm in length, of typical amphipod shape, and with banded coloration. G. daiber was only recently described (Bousfield 1969), and the species was (and continues to be) confused with the freshwater G. fasciatus, or a sibling species G. tigrinus (e.g., in Cory 1967).

Range:

G. daiberi ranges along the mid-Atlantic states from New York at least to South Carolina, in oligohaline and low mesohaline environments. In Chesapeake Bay, it is restricted to the upper third of the Bay mainstem and to the lower salinity areas of tributaries. Densities are typically less than $500/m^2$, and most commonly under $100/m^2$; however, more than 4000 individuals per m^2 have been recorded under exceptional conditions. There is some problem in delineating the range of this species within Chesapeake Bay, because of the taxonomic problem. Diaz (1977) found G. fasciatus and G. daiberi to have disjunct occurence in the James River: G. fasciatus was found from approximately river mile 50 upstream, in less than 0.1‰ salinity, while G. daiberi was collected from river mile 25 (between 1 - 5 ‰) upstream to mile 35 or 40 (over 0.1‰). Possibly many records of "G. fasciatus" in oligohaline areas are actually G. diaberi.

G. daiberi may occur pelagically within its range; Ginn *et al.* (1976) found it to be the most abundant planktonic macroinvertebrate in the Hudson River near Indian Point. Bousfield (1969) notes that planktonic populations are most numerous during spring and summer. It has been recorded from floating objects in salinities up to 14 ‰ (Bousfield 1969).

Female *G. daiberi* are smaller than the male (6 - 8 mm). Eggs are fertilized in the females' brood chamber, where they are held until hatching. There are no planktonic stages, and development is direct.

Salinity Relationships:

From collection information , *G. daiberi* is found with greatest frequency between the salinities of 1 - 5‰, although it occurs from 0.5 - 7‰. Bousfield (1969) also reports it from higher salinity areas, taken in plankton or floating material.

Other Sensitivities:

G. daiberi appears relatively tolerant of temperature extremes, surviving temperature increases to approximately 34°C with no loss of reproductive ability (Ginn *et al.*1976) Reproduction occurs mostly at warmer temperatures, but oviparous females have been recorded virtually year-round (Bousfield 1969).

G. daiberi is most numerous on substrates which provide some shelter or cover. Larsen (1974) recorded up to 3200 individuals per m^2 on oyster bars, while Diaz (1977) records maxima of less than 1/10 this value in soft substates.

Potential Habitat:

Areas from about 0.5 to 7‰, most abundant between 1 - 7‰ on all

types of sediment where suitable cover exists, to about 6 - 7 m depth. It may also occur pelagically at certain times of year within its range or somewhat downstream.

Trophic Importance:

Gammarus daiberi feeds upon a variety of material, including detritus, algae, fresh and decaying vegetation and animal matter, and small organisms.

Amphipods themselves are prey for a number of pelagic and demersal fish, shore birds, and a host of smaller invertebrate predators. Thomas (1971) found Gammarus (including fasciatus and daiberi) to comprise a high proportion of the food in young spot, silver perch, black drum, and weakfish in Delaware Bay. Thus G. daiberi, because of its abundance in the low salinity nursery areas of these and other species, is undoubtedly an important food resource and a key link in detritus-based food webs.

Selection Factors:

- Importance as a food for juvenile and adult fish, as well as its abundance in the low salinity nursery areas.
- Vulnerability to range reduction due to low flow conditions.

Sources:

Boesch 1971
Bousfield 1969
Cory 1967
Cory and Dresler, unpubl.
Diaz 1977
Ginn et al. 1976
Holland et al. 1980
Larsen 1974
Pfitzenmeyer 1976
Thomas 1971

Leptocheirus plumulosus - Amphipod (Map #42)

Description:

Leptocheirus plumulosus is a moderate-sized burrowing amphipod of the family Photidae. It is about 10 - 13 mm in length, and of typical amphipod outline, with heavily plumose setae on the gnathopods and peraeopods. It inhabits a tube constructed of sand grains and debris.

Range:

Leptocheirus plumulosus has been reported from Cape Cod to northern Florida, chiefly in estuaries and tidal ponds. In Chesapeake Bay, it is found from oligohaline waters to the upper mesohaline zone, primarily in shallower areas. It is often quite abundant, and densities of 3000 - 4000/m^2 are not uncommon, while 10,000 or more individuals per square meter have been recorded. Pfitzenmeyer (1970) characterized L. plumulosus as one of three permanent dominant upper Bay species (the others being Cyathura polita and Scolecolepides viridis).

L. plumulosus breeds in the warmer months, mostly during the period May through September, although Pfitzenmeyer (1970) found ovigerous females in October. Adults leave their burrows and a male grasps the female, which may be carried for a while before mating. The female broods the eggs, there are no planktonic stages, and development is direct. Each female produces two broods a year (Bousfield 1972). The young of the year overwinter, to breed the following spring. Densities of L. plumulo-

sus are generally highest in winter and early spring, and lowest during summer and fall (Holland et al. 1980). This may reflect both the action of predators, and the death of adults after breeding.

Salinity Relationships:

There apparently exists no laboratory information on the exact physiological tolerances of L. plumulosus. However, collection information indicates that it is generally restricted to areas where salinity is less than 15‰, and reaches greatest abundance from about 1 to 10‰.

Other Sensitivities:

No information is available on the exact temperature tolerances of L. plumulosus. Breeding, however, is apparently initiated in spring when water temperatures exceed 15°C or so.

L. plumulosus is found in all soft sediments: fine sand, muddy sand, sandy mud, and mud, as well as debris. Boesch et al. (1975) say that its prefered habitat is in shallow sand bottoms in oligohaline areas, but collection records report it in other sediments as well (Pfitzenmeyer 1970, Ecolog. Analysts 1974, Holland et al. 1979, 1980, and others). In hard substrates (firm sands, gravel, shell) it is replaced by another tube-building amphipod, Corophium lacustre. The species is adversely affected by sedimentation, which interfers with feeding. Gareth et al. (1975) noted that excess siltation following Tropical Storm Agnes limited L. plumulosus populations, and Bousfield (1972) notes that it occurs in areas with good circulation.

The species is definitely more abundant in shallow areas, which may reflect sediment preference, or sensitivity to summer hypoxia in deeper waters. Although recorded to depths of 15 m, it is most abundant in areas less than 10 meters.

Potential Habitat:

Potential habitat for this species is defined as areas 0.5 - 15‰ salinity, with highest populations between 1 - 10‰, all soft sediments, to 15 meters depth but most abundant in less than 10 meters.

Trophic Importance:

Leptocheirus plumulosus is a mixed deposit/suspension feeder, ingesting detritus, algae, microorganisms, and some animal and vegetable debris. It inhabits a relatively shallow tube, in which it lies oriented ventral side uppermost. Food is collected by action of the setose appendages and transferred to the mouth.

L. plumulosus represents a major source of food for benthic feeding predators, particularly fish, because of its abundance and wide distribution. Holland et al. (1980) suggest that the temporal distribution of the species indicates that its standing stock is controlled by predation. It showed one of the largest increases in exclosure cages, and Holland et al. (1980) cite Hixon (1978, 1979) that the species is frequently observed as a food item of bottom feeding fish.

Like all tube-building species, L. plumulosus contributes to sediment stabilization, sorting, and oxygenation.

Selection Factors:

- Dominance in oligohaline and low mesohaline areas, and possibility of range reduction due to low flow.
- Importance as a food item to bottom-feeding predators.

Sources:

Boesch, inpubl.

Boesch *et al*. 1975

Bousfield 1972

Cory and Dresler, unpubl.

Diaz 1977

Ecological Analysts 1974

Harman unpubl.

Hixon 1978, 1979

Holland *et al*. 1979, 1980

Pfitzenmeyer 1970, 1973, 1975

Pearson *et al*. 1975

Palaemonetes pugio - Grass shrimp (Map #43)

Description:

Palaemonetes pugio is a small (~3 - 4 cm) decapod of the family Palaemonetidae. It is of typical shrimp form, transparent greenish-grey in color; the first two pairs of legs are chelate and longer than the six walking legs, the rostrum is long, laterally compressed, with stout spines. Females tend to be larger than males.

Range:

Palaemonetes pugio is abundant in nearshore habitats along the Atlantic and Gulf coasts of North America. In many of these areas it occurs with its congeners P. vulgaris and P. intermedius, which has raised interesting questions as to habitat partitioning among these sympatric species. Palaemonetes typically inhabit areas which provide shelter, such as eel grass or other SAV beds, pilings, brush, cobbles, etc. and are less abundant along exposed shores. At high tide, they may enter marshes and feed upon detritus, algae, and small organisms.

In Chesapeake Bay, P. pugio is most abundant in oligohaline to polyhaline waters, although it has been found occasionally in tidal freshwater. In high mesohaline polyhaline areas it co-occurs with P. vulgaris, the importance of which increases seaward.

P. Pugio zoea are released into the plankton starting in early summer, and continue to be found until September. The larvae are most abundant in the bottom water layers where the net transport is upstream, and apparently utilize the characteristic two-layered estuarine circulation to retain themselves within the estuary.

Palaemonetes is abundant in its nearshore habitat until the coldest months, where it apparently retreats to deeper waters to overwinter.

Salinity Relationships:

In Chesapeake Bay, *P. pugio* is found from 0 - 1‰ to approximately 20‰ salinity. *P. vulgaris* is of increasing importance above 15‰ at this point, the two species tend to occur in approximately equal numbers (Bowler and Seidenberg 1971).

Because of the differences observed in the distributions of *P. pugio* and *P. vulgaris*, numerous laboratory investigations have been made in an attempt to elucidate the habitat partitioning between the two species. In general, the larvae of both species appear to develop best at higher salinities; *P. pugio* larvae have an optimum range of 15-35‰ with development significantly retarded below 10‰ (Broad and Hubschuman 1962, Sandifer 1973, McKenney and Neff 1979). Some laboratory studies have shown adults of *P. pugio* to be tolerant of low salinities, with several investigators citing 3‰ as the lethal lower limit for *P. vulgaris* (Nagabhushanam 1961, Wood 1967, Knowlton and Williams 1970, Bowles and Seidenberg 1971, Thorp and Hoss 1975). However, the latter authors found that, above 3‰, both species were equally tolerant to salinity, and that salinity *per se* does not mediate habitat partitioning.

Welsh (1975) found *P. pugio* to be far more tolerant of low dissolved oxygen, high detritus, and poor circulation environ-

ments than is P. vulgaris, and that these are probably the major environmental variables affecting the two species distributions.

Other Sensitivities:

P. pugio is also affected by temperature. Reproduction occurs when water temperatures warm in spring, with larvae released at about 18-20°C. Optimum survival and development occurs at 20-25°C. Juveniles are stressed at temperatures below 11°C, and survival is best at 18-25°C (Wood 1967). The increase of proportion of P. pugio to P. vulgaris in high salinity areas in winter reported by Thorp and Hoss (1975) for Rhode Island may reflect downstream migration of the former species (as does Crangon in winter). P. pugio is restricted by availability of shelter, and has thus been affected by the recent bay-wide decline in SAV's.

Potential Habitat:

Potential habitat for this species is defined as areas between 1-20 ‰ salinity, where suitable cover exists; it is generally found in less than 3-4 meters water.

Trophic Importance:

Palaemonetes pugio is an important food organism for fish, particularly those species inhabiting nearshore areas (eg. Fundulus).

P. pugio is particularly important, however, as a detritivore and nutrient recycler (Welsh 19'5). The shrimp ingests detritus from marshes, as well as attached algae such as Ulva and diatoms, and assimilates the detritus and associated bacteria. The mechanics of feeding also tend to "mill" or reduce the detritus particle

size enhancing decomposition. *P. pugio* thus represents a major pathway for transfer of energy and material from tidal marshes to higher trophic levels.

Selection Factors:

- Importance of estuarine circulation to maintenance of species within the estuary, and in transport of larvae from higher salinity areas where development is maximal to low salinity parts of range.
- Potential reduction of range downstream due to salinity increase.

Source:

Bowles and Seidenberg 1971

Broad and Hubschman 1962

Cargo 1977

Knowlton and Williams 1970

Lippson *et al.* 1979

McKenney and Neff 1979

Nagabhushanam 1961

Sandifer 1973, 1975

Thorp and Hoss 1975

Wass *et al.* 1972

Welsh 1975

Wood 1967

Alosa pseudoharengus - alewife (Map #44)

Description:

The alewife is a member of the herring family, Clupeidae. The species of the genus Alosa are collectively known as river herring. The river herrings are marine fish making spawning migrations into rivers well into freshwater. The color of the alewife is gray-green on the back, silvery on the sides. The alewife grows to 38 cm.

Range:

The alewife enters Chesapeake Bay and migrates up the major tributaries in late March when the water temperature reaches 10.5°C. The alewife migrates to freshwater. It spawns in slower, shallower reaches of creeks and rivers, never spawning in turbulence and fast water. Migration may continue through mid-May or until the water temperature reaches 28°C. During the spawning runs the alewife does not eat. The eggs are adhesive and tend to remain in the vicinity of spawning. The eggs hatch in one week at 15°C. The larvae are usually found within five miles of where the eggs were spawned.

After spawning the adults move downstream where they begin feeding. Depending on conditions they may move toward the ocean or remain in Chesapeake Bay until fall. Juveniles move down stream after a month. They reach the sea during the autumn at an average length of 10 cm.

Salinity Relationships:

- Eggs are found in freshwater < 0.5‰.
- Larvae are found in freshwater and into the oligohaline region (0-3‰).
- Juveniles are found in the oligohaline region through early fall.
- Adults - marine to freshwater. Landlocked freshwater populations exist outside Chesapeake Estuary.

Low Flow Sensitivities:

Spawning habitat is critically sensitive to the effects of low freshwater flows. Higher temperatures, lower dissolved oxygen levels and reduced water quality are all areas of concern. Movement of the 0.5‰ isohaline upstream in rivers where the fish's passage is restricted by falls, dams or obstructions a reduction in size of spawning habitat will result. This may result in overcrowding on the spawning grounds or increased spawning in marginal habitat.

Potential Habitat:

The only relevant potential habitat is spawning habitat which requires shallow slow flowing freshwater between 10.5°C and 28°C with debris in it.

Trophic Importance:

The alewife is a seasonally abundant fish feeding chiefly on zooplankton, particularly copepods. The alewife will also take young fish when they are available. Alewives of all ages serve as food for large bluefish, striped bass and other top predators.

Selection Factors:

The alewife is a fairly abundant river herring with sport and commercial importance. It shares many life history characteristics with the shad.

Sources:

Annon. 1968
Carter 1973
Dovel 1971
Hildebrand and Schroeder 1928
Johnson _et al_. 1978
Jones _et al_. 1978
Kaufman _et al_. 1980
Lippson and Moran 1974
Lippson _et al_. 1979
Lippson (unpub.)
O'Dell _et al_. 1976
Raney and Massmann 1953
Ritchie and Koo 1973
Wang and Kernehan 1979
Whitney 1961

Alosa sapidissima - American shad (Map #44)

Description:

The shad is a member of the herring family, Clupeidae. The shad is the most sought after of the river herrings. Shad is an anadromous spawning marine fish. Color of the shad is dark blue to green on the back fading to silvery-white on the sides. The shad grows to 75 cm and is highly prized for its flavor and for the caviar-like shad roe.

Range:

The shad enters coastal waters as they warm in the spring. Usually in March, when the water temperature in Chesapeake Bay has reached 13°C the fish begins its spawning run up the rivers. Where the rivers are not blocked by dams or other obstructions shad will move long distances upstream (formerly as far as 480 km up the Susquehanna). Most spawning currently is located much closer to the salt water interface due to the prevelence of stream obstructions. Spawning occurs in rapidly flowing water over clean sand or gravel bottom. Eggs are nonadhesive and rolled along with the current. In larger rivers spawning tends to occur in the channels. Eggs hatch in two weeks at 11°C. Juvenile shad remain in the river until fall at which time (around October) they leave for the ocean. Adults return to sea after spawning. They have generally left the Bay by the end of June.

Salinity Relationships:

- Eggs - freshwater $<0.5‰$.
- Larvae - freshwater to oligohaline $<5‰$.
- Juveniles - oligohaline region into low mesohaline $<12‰$ gradually moving into more saline regions.
- Adults - freshwater to euhaline (oceanic).

Low Flow Sensitivities:

A. sapidissima require flowing freshwater with dissolved oxygen levels above 5 ppm and clean sand or gravel bottoms. High temperatures, above 21°C, and low D.O. levels are detrimental to hatching. Local reaches of rivers with depressed D.O. have proved to be a barrier to the downstream migration of juveniles. Physical barriers to spawning migrations are sufficiently prevelent even on minor tributaries that the population has suffered severe decline. Intrusion of salt into the remaining spawning reaches below dams and barricades may be sufficient to eliminate entire year classes.

Potential Habitat:

The only relevant potential habitat is a spawning habitat which requires temperatures 13° - 17°C, freshwater, current, and adequate dissolved oxygen.

Trophic Importance:

Adult shad feed mainly on copepods in the surface layer. Other small fish and planktonic crustaceans form a small part of the diet. The trophic impact of shad on Chesapeake Bay is limited by the pattern of not eating during migration and prompt return to the ocean after spawning by the adults. Juvenile shad are planktivores and form an important prey resource for top predators.

Selection Factors:

Offshore overfishing, water quality problems in spawning rivers and greatly restricted access to spawning habitat have contributed to a drastic population decline in the Maryland tributaries. Maryland Department of Natural Resources has closed the fishery for shad for the indefinite future. The species is already under considerable stress which has reduced the resiliancy of the Chesapeake Bay populations. Additional restrictions of spawning habitat due to upstream displacement of salinity is likely to produce an immediate and abrupt result.

Sources:

Annon 1968
Carter 1980
Dovel 1977
Env. Serv. Dept. VEPCO 1976
Hildebrand and Schroeder 1928
Johnson *et al*. 1978
Jones *et al*. 1978
Lippson and Moran 1974
Lippson *et al*. 1979
Neves and Depres 1979
Raney and Massman 1953
Scott and Boon 1973
Wang and Kernehan 1979
Whitney 1961

Brevoortia tyrannus - Atlantic menhaden (Map #45)

Description:

The menhaden is a member of the herring family, Clupeidae. The adult menhaden is a marine spawner which is dependent on the estuary both as a nursery for juveniles and which use the estuary as a feeding grounds during the summer months. The adult fish is dark blue to green with a conspicuous dark spot behind the head. Menhaden grow to a length of 46 cm and is the single most important non-food fish on the east or Gulf coast.

Range:

Menhaden enter Chesapeake Bay from the ocean in April and remain until October. Post-larval menhaden enter the Bay during the winter or early spring from spawning areas on the continental shelf. Post-larvae accumulate at the fresh salt water interface. After metamorphosis the juveniles begin to move from the fresh water interface through the oligohaline zone into the mesohaline. Larger fish are found in deeper water and further down the Bay. After metamorphosis the fish become pelagic feeders. Sub-adults will leave the estuary with the adults in October.

Salinity Relationships:

- Eggs - oceanic
- Larvae - oceanic drifting to tidal fresh on the bottom current.

- Juveniles - moving generally in surface layer from oligohaline to euhaline (oceanic).
- Adults - wandering from mesohaline (5 ‰) to euhaline with areas of concentrated adults and juveniles (5-8‰) following plankton patches.

Low Flow Sensitivities:

Change in stratification and net upstream drift of bottom waters could change delivery of larvae to low salinity nursery area. Breakdown of stratification could disperse plankton concentrations and make feeding more difficult for adults.

Potential Habitat:

Nursery area is the only critical habitat, potential nursery area described by salinity within the 0‰ to 5‰ zone, shallow waters, with organic bottom sediments and high plankton productivity.

Trophic Importance:

The only forage fish feeding directly on primary producers, menhaden are a major energy pathway from plankton direct to large piscivores. Present in exceedingly dense aggregations, the filter feeding of menhaden is a primary limit to plankton abundances.

Selection Factors:

- Unique trophic importance.
- Dependence on estuarine circulation for reproduction
- Dependence on high primary productivity of turbidity maximum.

Sources:

Beauchamp 1974

Colton et al. 1979

Dovel 1971

Durbin 1976

Harrison et al. 1967

Hildebrand and Schroeder 1928

Jones et al. 1978

Lewis 1966

Lippson et al. 1979

Massman et al. 1962

McHugh et al. 1959

Oviatt et al. 1972

Ritchie and Koo 1973

Scott and Boone 1973

Wang and Kernehan 1979

Weinstein 1979

ANCHOVY

Anchoa mitchilli - Bay anchovy (Map #46).

Description:

The Bay anchovy is a delicate, soft bodied small fish with large eyes and an underslung jaw giving it a "chinless" profile. The Bay anchovy belongs to the family Engraulidae. The Bay anchovy grows to a length of 10 cm and is translucent with a narrow horizontal silvery stripe along each side. The Bay anchovy is more inshore and estuarine oriented than is *Anchoa hepsetus* with which it competes in the higher salinity regions.

Range:

The Bay anchovy is found in open water throughout the Bay from the freshwater zone to the euhaline zone. However, spawning is concentrated in a much narrower salinity range (5 to 15‰), with peak egg densities only in 12-13‰ salinities in Chesapeake Bay. Other estuaries to the south have different spawning salinity relationships. Spawning is pelagic. Larvae move shoreward, remain in the surface waters and appear to collect in the area of salinities between 3 and 7‰. Juveniles are pelagic, shoreward oriented and euryhaline. Juveniles have been recorded far upstream of the limit of tidal influence in Virginia rivers. The juveniles are most abundant at the salt-freshwater front.

Salinity Relationships:

- eggs - 5-15‰, max. concentration 12-13‰.
- larvae - 3-7‰.
- juveniles - 0-35‰, max concentration 0.5 -3‰.
- adults - 0-35‰.

Low Flow Sensitivities:

The most sensitive life stage appear to be that of the larvae which collect in the surface waters of the oligohaline salinity zone. Movement of the oligohaline region into narrower regions of the tributary extuaries will concentrate the larvae and reduce the area available for feeding and growth. Larvae and early juveniles are dependent on the density of copepod nauplii for food. Crowding may well result in food limitation and reduction in size of year class of these important forage fish.

Potential Habitat:

Potential spawning habitat is open Chesapeake Bay water with a salinity between 5 and 15‰. Potential habitat of larvae is the shallow shore zone where the salinity is between 3 and 7‰, while the adults habitat is all open water from tidal fresh to the ocean (euhaline zone).

Trophic Importance:

Young anchovy feed exclusively on copepods. They may compete with alosid larvae for copepods, where ranges overlap. Adult anchovy feed upon copepods and other planktonic crustaceans such as crab larvae, mysids and cladocerans. In some areas larval fish are also taken by adult anchovy, however this does not occupy a substantial portion of thier diet. In turn, the Bay anchovy is fed on quite heavily by white perch and yellow perch, young bluefish and young striped bass. Juvenile weakfish are parti-

cularly dependent on anchovies for forage fish. In addition to its high abundance the anchovy is important as a forage fish because of its presence in the Bay year round.

Selection Factors:

The sensitivity of the larval stage to salinity the importance of the anchovy as a forage fish and its high biomass and wide distribution are all factors which contributed to the selection of the Bay anchovy as a study species.

Sources:

Carter 1973
Dovel 1971
Homer and Boynton 1978
Hildebrand and Schroeder 1928
Jones *et al*. 1980
Lippson and Moran 1974
Lippson *et al*. 1979
Lippson (unpubl)
Raney and Massmann 1953
Scott and Boone 1973
Wang and Kernehan 1979

Leiostomus xanthurus - Spot (Map #47)

Description:

The spot is a member of the drum family, Sciaenidae. It is a relatively small drum growing to a maximum length of 34 cm. The spot has a deep, compressed body, with inferior mouth. The color of the spot is bluish gray with a large black shoulder spot from which it gets its name. This fish is presently the most abundant sciaenid in Chesapeake Bay.

Range:

The spot is widespread in Chesapeake Bay from early April through early November. The spot spends the winter on the continental shelf where it spawns. Post-larvae enter the Bay in the spring in the net upstream flow of bottom water. Metamorphosis apparently occurs in transit or soon after the fish arrives on the nursery grounds. Newly arrived young spot congregate in the oligohaline zone although during periods of high population densities some young move into fresh water and into shallow marshes and drainage ditches. As the spot grows it tends to move toward deeper and saltier water. Adults are found in mesohaline to euhaline salinity zones. Adults and juveniles tend to prefer soft muddy bottoms. Spot leave the Bay as water temperatures cool in the fall. Fish in their second or third year of life do not penetrate very far into the estuary, being found in any numbers only in the lower Virginia position of the Bay.

Salinity Relationships:

- juveniles - tidal fresh to oligohaline, spring through fall.
- adults - mid mesohaline to euhaline, spring through fall.

Low Flow Sensitivities:

The transport of the larvae from ocean to the nursery grounds is dependent on the hydrology of the partially mixed estuary. Low inflow conditions may act to reduce stratification and slow the inward movement of oceanic water. A sufficient delay in the passage of young fish to the nursery grounds could result in metamorphosis occurring early before the necessary quantities of appropriate food is reached. Spot on the nursery grounds are highly dependent on harpacticoid copepods such as Scottolana which reach high densities only in the oligohaline zone.

Potential Habitat:

Summer salinities between tidal fresh and oligohaline and depths of three meters or less are nursery habitat for juvenile spot. Adult spot habitat is defined as mid-mesohaline to euhaline in depths to six meters over bottoms of soft sediment.

Trophic Importance:

Spot juveniles can be quite dense on the nursery areas in some years and not in other years. This has a profound effect on the numbers of benthic harpacticoid copepods. Adult spot are the most important benthic grazers on small crustaceans, annelids, small molluscs and fish. The majority of the production of the soft bottom benthic community is grazed by spot. Spot are preyed upon by large gamefish and by the sport and commercial fishery. Spot also serve as an export of energy

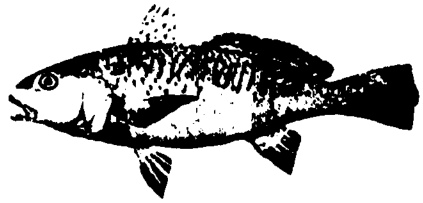
from the estuary to the shelf.

Selection Factors:

The sensitivity of juveniles to changes in Bay circulation, the requirements of juveniles for particular substrate-food combinations, the abundance of spot and its importance as a benthic grazer of invertebrates are the primary reasons for its selection as a study species.

Sources:

Chad and Musick 1977
Environ. Serv. Dept. VEPCO 1976
Haven 1957
Hildebrand and Schroeder 1928
Homer and Boynton 1978
Johnson 1978
Joseph 1972
Kaufman *et al*. 1980
Lippson *et al*. 1979
Ritchie and Koo 1973
Scott and Boone 1973
Wang and Kernehan 1979
Weinstein 1979



CROAKER
RANGE - GULF OF MEXICO TO NEW YORK

Micropogonias*undulatus - Atlantic croaker (Map #47).

Description:

The Atlantic croaker is a member of the drum family, Sciaenidae. The croaker is larger than its relative the spot, reaching a maximum length of 50 cm. The croaker is distinguished by numerous small barbels under the mandable and a wedge shaped caudal fin. The back of the fish is a greenisn-silver with wavy vertical lines of dark spots. The Atlantic croaker is subject to a sport and commercial fishery throughout the southern Atlantic and Gulf coasts.

Range:

Adult Atlantic croaker enter Chesapeake Bay from the ocean in late March or early April as the water warms. Croaker are more numerous in Virginia's portion of Chesapeake Bay, however, during periods of high population densities , the fish will be found further north to salinities of 10‰. Croaker prefer deeper water than spot and are found in channels and in the vicinity of oyster reefs. Adult croaker have been reported in permanent fresh water in St. Johns River, Florida. Larger individuals tend to remain in higher salinities and spawning individuals leave sooner than juveniles. All spawning fish have left by mid-Sept. while immatures may remain as late as early December during mild winters.

Larvae enter Chesapeake Bay from the ocean beginning in September and continuing through the winter. Larvae drift with the bottom layer of inflowing sea water. Transforming larvae accumulate in fresh water just above the fresh-salt interface. As the

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* Renamed Micropogonias by Chao. Micropogon preoccupied by a bird genus, Bore 1827.

AD-A125 262 CHESAPEAKE BAY LOW FRESHWATER INFLOW STUDY BIOTA ASSESSMENT PHASE I APPENDICES(U) WESTERN ECO-SYSTEMS TECHNOLOGY INC BOTHELL WA G B SHEA ET AL. AUG 80 3/3

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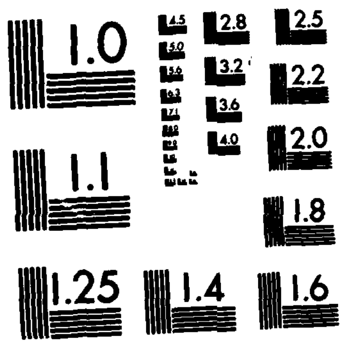


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

juveniles grow they tend to move into deeper and more saline waters. Depending on growth rates juveniles may remain in the estuary one to two years before migrating to the ocean.

Salinity Relationships:

- Eggs - Euhaline, spawning is in the ocean
- Larvae - euhaline to fresh, simi passive movement
- Juveniles - fresh to low mesohaline during first winter moving down Bay during late summer
- Adults - euhaline to high mesohaline during March through September.

Low Flow Sensitivities:

Change in stratification and net upstream movement of bottom waters could change transport of larvae from ocean to nursery area. Juveniles on nursery grounds are highly dependent on harpacticoid copepods such as Scottolana. Changes in conditions in the fresh-oligohaline region which impacts Scottolana would reduce the food supply available to the transforming larvae and juveniles.

Adults would be likely to expand their range in an upBay direction if the salinity isohalines progress up the Bay.

Potential Habitat:

Potential nursery habitat is the 0 to 5‰ salinity zone in winter with cooccurance of harpacticoid copepods. Potential adult habitat is hard bottom in three meters or greater water depths and a salinity between 10 and 34‰.

Trophic Importance:

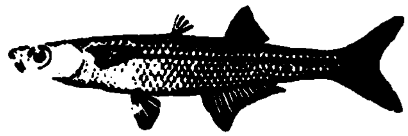
The Atlantic croaker feeds on a wide variety of small benthic invertebrates, primarily crustaceans and molluscs. The croaker is a food fish caught in considerable numbers by recreational fishermen and commercial fishermen.

Selection Factors:

- Dependence of larvae on Bay circulation
- Requirement of early juveniles on one type of food
- Sensitivity of early life stages to substrate
- The importance of adults and juveniles as consumers of benthos
- The value of the fish to the fishery

Sources:

Chad and Musick 1977
Dovel 1968
Haven 1957
Hildebrand and Schroeder 1928
Johnson 1978
Joseph 1972
Kaufman *et al*. 1980
Massmann and Pacheco 1960
Wallace 1940
Weinstein 1979



Menidia menidia - Atlantic silverside (Map #48)

Description:

The silverside family is Atherinidae. The Atlantic silverside is an inshore schooling forage fish of the tidal regions. They feed in marshes on the flood tide and are strongly oriented to estuaries. Superficially the silverside looks similar to an anchovy. The color of the live fish is pale, translucent green. The wide silver horizontal band on the fish is edged with black, the mouth is oblique and there are two well separated dorsal fins. The scales of the Atlantic silverside are smooth, which easily distinguishes it from the rough silverside which has rough scales. The Atlantic silverside grows to a maximum length of 14 cm.

Range:

The Atlantic silverside is widespread and abundant throughout the lower tributaries and main stem waters of Chesapeake Bay. Upstream penetration into freshwater is evidently limited by competition with the tidewater silverside M. beryllina. Feeding adults are associated with emergent vegetation and marshes. Spawning also occurs in the intertidal region and in shallow SAV beds. The eggs are provided with adhesive filaments and become attached to sedges, eelgrass, sand and beach trash. Juveniles tend to prefer vegetated bottom more than adults, which tend to be found over sand bottom when not feeding.

Salinity Relationships:

- eggs - 3-14‰ preference, 1-34‰ range
- larvae - 3-14‰ preference, 1-34‰ range
- juveniles - 3-14‰ preference, 1-34‰ range
- adults 3-14‰ preference, 1-34‰ range

This salinity distribution results from competition and possibly predation rather than physiology. Lab studies and records from locations other than Chesapeake Bay indicate survival from 0 to 34‰. In lab studies larval survival is higher at higher salinities as is egg hatching success.

Low Flow Sensitivities:

The upstream boundary of this species is apparently due to species competition. An expansion of this species in an upstream direction could be anticipated where wetlands border the tributaries.

Potential Habitat:

There is insufficient information on the distribution of the Atlantic silversides in the higher salinity regions of the lower eastern shore to determine whether the silverside is abundant there outside of its preference zone, as found in western shore tributaries. Therefore the potential habitat as mapped is from 3 to 34‰ salinity in the shallow shore regions of hard bottoms.

Trophic Importance:

The Atlantic silverside is abundant in the shore zone throughout much of the Bay and tributary estuaries. The shoreward orientation of the silverside in contrast to the pelagic anchovy means that the silverside is fed on by different predators than the anchovy or by different life stages of the same predator. The silverside is soft bodied and fragile. They are difficult to capture alive and to maintain in the lab. As a consequence less is known in quantitative terms about the Atlantic silverside role in the flow of energy in the estuary but it is quite

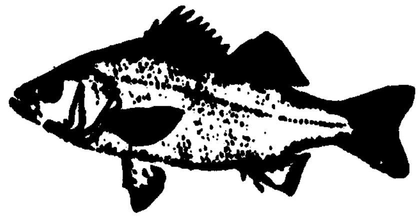
important to juvenile blue fish and juvenile striped bass. In turn the silverside preys on small crustaceans, worms, insects and epiphytic algae.

Selection Factors:

The Atlantic silverside is the most abundant of all Atherinidae in Chesapeake Bay. By grazing in the marshes it serves as a form of energy importer to the aquatic portion of the estuary. In turn the Atlantic silverside is an important item of diet for game fish species.

Sources:

Dovel 1971
Hildebrand and Schroeder 1928
Lippson 1973
Lippson *et al*. 1979
Raney and Massman 1953
Scott and Boone 1973
Wang and Kernehan 1979
Weinstein 1979
Wheeler 1975



WHITE PERCH
RANGE - NORTH CAROLINA TO MAINE

Morone americana - White perch (Map #49).

Description:

The white perch is a member of the family Percichthyidae, the temperate basses. The white perch is an anadromous species which is occasionally has local populations confined to fresh water. The perch does not wander far from its natal river system. The white perch is a relatively deep bodied fish with separate spiny and soft dorsal fins, plain silver color without stripes or spots. The white perch grows to a maximum length of 49.5 cm.

Range:

The white perch is found throughout the Chesapeake Bay and C & D canal. They have been reported from marine areas north of Chesapeake Bay. White perch move upstream in the spring into the shore zone in tidal freshwater to spawn. Spawning occurs on shoal hard bottoms, (eg. sand or gravel) where there is current. Juveniles remain in shallow, soft bottomed nursery areas, preferably in areas of vegetation, for their first year. Juveniles larger than 25 mm total length begin inshore-offshore movements related to light levels. Cold temperatures cause white perch to move into deeper waters. Wintering populations are found in the deeper channels and holes in the Bay.

Salinity Relationships:

- eggs are found in fresh to oligohaline waters, maximum salinities 4.2‰, mapped 0-5‰.
- larvae are found in fresh to oligohaline water, maximum salinities 8.0‰, but prefer less than 1.5‰, mapped
- juveniles are found in fresh to low mesohaline waters, maximum 13‰ but prefer less than 3‰, mapped 0-5‰.
- adults range from fresh water to 30‰ but prefer salinities between 4 and 18‰, mapped 5-18‰.

Higher temperatures have the effect of reducing maximum salinities in which white perch are found.

Low Flow Sensitivities:

Spawning habitat is the critical life history stage subject to effects of low flows. Increased salinity or increased siltation due to restricted freshwater inflow may impact the spawning area by restricting the available habitat through up-stream displacement of the salinity zone and smothering of eggs adhering to the substrate, usually clean sand or gravel.

Potential Habitat:

Mapped potential habitat shows the area of the salinity preference zones (5 to 18‰) and the spawning habitat between 0 and 5‰ in shoal areas. Although white perch will be found outside of these preference areas the metabolic cost of existence in the marginal area is greater than the preferred region.

Trophic Importance:

White perch is the single most abundant species in many areas of the mid and upper Bay. The white perch is a generalized

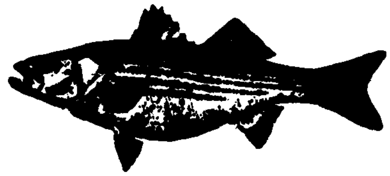
feeder eating fish, crustaceans, annelids and insect larvae. In turn, small white perch are eaten by top predators such as blue fish and striped bass.

Selection Factors:

White perch are a major biomass contributor in areas of the estuary and its distribution is well documented. The location of spawning is dependent on the salinity and velocity regime of the subestuaries which will most likely be affected by consumptive water losses and drought.

Sources:

Dovel, W. 1971
Env. Serv. Dept. VEPCO 1976
Hardy, J. 1978
Lippson, A.J. et al. 1979
Lippson, R. (unpubl.)
Loo, J. 1975
Mansueti, R. 1961
Mansueti, R. 1964



STRIPED BASS

Morone saxatilis - Striped bass (Map #50).

Description:

The striped bass is a close relative of the white perch. A member of its family Percicthyidae, the striped bass is an anadromous marine game fish which can grow as large as 127 cm. The fish is olive green shading to white on the ventral surface. with seven dark horizontal stripes which gives the species its common name. It is highly prized as a sport fish and is also netted commercially in Chesapeake Bay. The Chesapeake provides in excess of 80% of the Atlantic coastal striped bass stock.

Range:

Within Chesapeake Bay the striped bass is found from the ocean to the fall line. Formerly striped bass ascended far up the Susquehanna River but the route is presently blocked by dams. The Chesapeake and Delaware Canal is used both for migration to and from Chesapeake Bay and as a major spawning area. Younger fish tend to be found in shallower and less saline water. During summer the striped bass is oriented to high energy shorelines, (rocky points, beaches, hard bottom where there is a current). During the winter striped bass seek out deep holes and channels where they remain relatively inactive. Larger fish are found in the high mesohaline to low polyhaline regions along the bottom. Younger fish may be found further upstream in winter,

also in deep water.

Salintiy Relationships:

- eggs - tidal fresh to 1‰.
- larvae - tidal fresh to oligohaline
- juveniles - tidal fresh to mesohaline
- adults - spawning migrations to freshwater, otherwise mid-mesohaline to euhaline.

Low Flow Sensitivities:

Spawning requires turbulent water to keep the eggs in suspension. Spawning is apparently successful only in turbulent silty areas of rocky or hard bottoms and only in fresh water. Some studies have indicated that fish will not enter a river during periods of low discharge from upstream dams while restoring the reservoir water levels. This will be one of the anticipated effects of the regularizing of the river flow resulting from the construction of additional impoundments.

Potential Habitat:

Potential spawning habitat as mapped includes some areas where striped bass have been reported to have spawned in the past but which are not now used for spawning. Within the recent past spawning areas have shifted up and down rivers such as the Potomac due to hydrologic variables and chemical pollutants. Potential habitat for spawning is defined as tidal fresh water in mid-channel in regions of turbulent river flow. Habitat for juvenile striped bass is the shore zone in the oligohaline and low mesohaline salinity zones. Summer habitat for adults is the mid-mesohaline to euhaline salinity zones in water six meters or less deep while winter habitat for adults is depths greater than six meters and salinities from mid-mesohaline to

euhaline.

Trophic Importance:

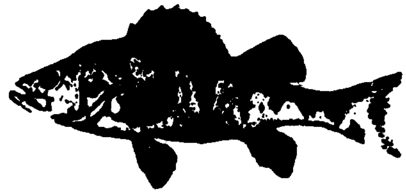
Striped bass are large active predators feeding on a wide variety of fish and crustaceans. Larval striped bass are dependent upon the densities of copepod naupleii and other very small planktonic crustaceans. As the striped bass grow, their size of the prey increases also. Large striped bass have been accused of making severe inroads on populations of juvenile Atlantic croaker over the winter. The most significant predator on adult striped bass is man. The sport fish landings may exceed the commercial fisheries landings by approximately a factor of two.

Selection Factors:

The large number of studies on the biology and distribution of the striped bass, the sensitivity of its egg and larval stages to the circulation and salinity changes expected to occur during low flow conditions and high trophic importance were all contributing factors in the selection of the striped bass as a study species. In addition, the fish has a high economic and social importance which, interacting with concern about the decline in fish recruited to the fishery, make this study species of considerable interest.

Sources:

Carter 1973
Dovel 1971
Environ. Serv. Dept. VEPCO 1976
Harcy 1978
Hildebrand and Schroeder 1928
Kaufman et al. 1980
Lippson and Moran 1974
Lippson et al. 1979
Mihursky et al. 1970
Miller 1978
Ritchie and Koo 1973
Scott and Boone 1973
Talbot 1966
Wiley et al. 1978



YELLOW PERCH

Perca flavescens - Yellow perch (Map #51).

Description:

A member of the family Percidae, the yellow perch is a native of central North America. The yellow perch requires slow flowing rivers, with vegetation, submerged trees or pilings. The yellow perch is a deep bodied green fish with broad vertical black bars on its back and distinct yellow-orange fins. Yellow perch grow to a length of 53 cm. Yellow perch are a popular sport fish of the upper reaches of the estuary.

Range:

Yellow perch are found from non-tidal fresh water to salinities of 13‰ in all coastal waters tributary to Chesapeake Bay. They are able to tolerate low oxygen levels and remain active even under winter ice. Yellow perch make vertical temperature dependent migrations and inshore, upstream spawning migrations. Spawning occurs in shallow waters often with debris or vegetation present. Eggs are adhesive and form ribbon-like clumps attached to each other and to branches, roots and gravel. Spawning occurs in March and April in both tidal and non-tidal freshwaters. Females move down river soon after spawning while males remain upstream for longer periods. Juveniles move to aquatic vegetation in the oligohaline and low mesohaline zones where they tend to form large pelagic schools. Adults become demersal with a preference for soft mud bottoms.

Salintiy Relationships:

- eggs-0 to 0.5 ‰ freshwater
- larvae- 0 to 0.5 ‰ shallow freshwater
- juveniles-0.5 to 10‰ tidal fresh to mesohaline
- adults- 0 to 13‰ , tidal fresh to mesohaline regions, seasonal migrations for spawning and temperature regulation.

Low Flow Sensitivities:

Spawning very sensitive to river flow. Changes in water level strands eggs out of water or washes them off their attachments. Low flow conditions are expected to be favorable for spawning of yellow perch by reduction of current and regularization of of water levels in major tributaries. Changes in salinity zones with respect to soft mud bottom habitat could affect feeding patterns of adult.

Potential Habitat:

Spawning habitat is defined as shallow areas in the tidal freshwater portion of the study area. Although the adult yellow perch has been recorded at depth above 27 meters, most specimens prefer shallower regions. The yellow perch is an epibenthic feeder preferring but not restricted to soft bottom. The mapped potential habitat is between the lower limits of tidal fresh water to mid-mesohaline salinity zones, oriented to the shore zone in summer and oriented to the deeper waters in winter.

Trophic Importance:

The principal foods of the young perch in fresh water are insects and small crustaceans. The adult, in the estuarine portion of its range feeds on soft bodied fish, minnows and anchovies as well as isopods, amphipods, shrimp and snails. The yellow perch is an important competitor in the oligohaline and lower mesohaline zone where large populations can cause stunting of the adults. In the upper Bay the yellow perch is the second most numerous fish, after the white perch, and exerts considerable feeding pressure on the smaller fishes and invertebrates. The yellow perch is a popular sport fish.

Selection Factors:

Large biomass, competition with other species and the sensitivity of the early stages to changes in hydrology due to low flows are the main reasons for the selection of this species.

Sources:

Carter 1973
Dovel 1971
Hardy 1978
Hildebrand and Schroeder 1928
Kaufman *et al*. 1980
Lippson 1973
Lippson and L. Movan 1974
Lippson *et al*. 1979
Lippson (unpubl)
Mansueti 1964
Raney and Massman 1953
Ritchie and Koo 1973
Schwartz 1964
Wang and Kernehan 1979

Anas platyrhynchos - Mallard (Map # 52).

Description:

The mallard is a member of the dabbling duck subfamily Anatidae. The drake mallard is well-known, with a iridescent green head chestnut breast, white neck ring and yellow beak. The hen is mottled brown; both sexes have a iridescent blue speculum on the wing.

Range:

Mallards are very abundant migrants and winter residents in the Chesapeake Bay area, and are one of the most desirable and heavily hunted of the Bay ducks. A few birds breed in the Bay area during the summer months. In the 1980 Maryland mid-winter waterfowl survey, areas of high mallard abundance include the Chester, Wye, Manokin, and Pocomoke Rivers. Prior to 1980, the upper Patuxent and Potomac Rivers also supported high abundances of mallard. In the Virginia waters of Chesapeake Bay areas of high abundance, as reported in the 1980 Virginia mid-winter survey, include the upper Pamunkey, James and the Rappahannock Rivers.

Salinity Relationships and Sensitivities:

Mallards are most abundant in shallow fresh and brackish areas near agricultural fields, particularly in the upper tributaries. They also occur, although are usually not as abundant, in forested swamps and coastal salt marshes. Salinity will affect the bird only insofar as it affects its food and habitat.

Trophic Importance:

Mallards eat a large proportion of vegetable matter, and this diet includes a wide variety of plant material. The following

species were found to occur in more than 10% of the mallard gizzards examined by Rawls (in press):

- Nyssa silvatica
- Polygonum pennsylvanicum
- Polygonum punctatum
- Potamogeton perfoliatus
- Ruppia maritima
- Scirpus americanus
- Scirpus validus
- Zea mays

Animal remains accounted for less than 5% of the total food volume in these birds.

The mallard is one of the most desirable waterfowl for the sportsman, accounting for about 35% of the ducks harvested.

Other Factors:

The mallard is also of interest because of its hybridization with the black duck, an apparently increasing phenomenon on the Atlantic flyway (Morgan et al. 1976, Wass, pers. comm., Morton, pers. comm.). This hybridization may pose a threat to the survival of the black duck species in areas where the breeding zones of the two species overlap.

Selection Factors:

- Abundance of the species and importance to the waterfowl sport harvest
- Importance as a feeder on SAV's and EAV's
- Potential competitor with black ducks

Anas rubripes - Black Duck (Map #53).

Description:

The black duck is a dabbling duck, subfamily Anatinae of the family Anatidae. Male and female black ducks are simular, and in general resemble the female mallard but are darker. The body color is a dark mottled brown, and neck and head lighter brown, with an iridescent violet blue speculum on the wing.

Range:

Black ducks are present in the Chesapeake Bay area throughout the year. They migrate through the spring and fall, overwinter, and breed in the area during spring and summer. They are among the most abundant overwintering species, and are heavily hunted in the Bay area. In the 1980 Maryland mid-winter waterfowl survey, concentrations of black ducks were found in the Chester Wye, and Choptank Rivers. The Nanticoke, Wicomico, Manokin, and Pocomoke Rivers also were areas of black duck concentrations. In Virginia, the 1980 mid-winter survey found black duck concentrations in the James, Chickahoming, and Pamunkey Rivers. Pocomoke Sound and the Rappahannock also had substantial numbers of black ducks.

Salinity Relationships and Sensitivities:

Black ducks are found in a wide variety of habitats during the non-breeding periods of the year, although more abundant in tributaries and near shore. They seem to prefer nesting in wooded and brushy areas near creeks and marshes, particularly estuarine coastal marshes, although they also occur in coastal salt and fresh water marshes. Salinity changes would probably only affect the black duck through affecting food or habitat.

Trophic Importance:

Black ducks feed on both plant and animal material. Rawls (in press), found the following plant species in 10% or more of the 131 black duck gizzards examined:

- *Myriophyllum spicatum*
- *Polygonum* spp.
- *Potamogeton amplifolius*
- *Potamogeton perfoliatus*
- *Sparganium americanum*
- *Zea mays*

Animal matter comprised approximately 6% of the total food volume in these samples.

The black duck is one of the most valuable waterfowl for the sportsman, accounting for about 20% of the total kill.

Other Factors:

The black duck is undergoing introgressive hybridization with the mallard in some areas, and this is apparently increasing on the Atlantic flyway (Morgan et al. 1976, Wass, pers. comm., Morton, pers. comm.). This hybridization may pose a threat to the existence of the black duck as a species in areas where the two species' breeding zones overlap.

Selection Factors:

- Abundance of the species and importance to the waterfowl sport harvest.
- Importance as a feeder on SAV's and EAV's
- Potential competition from mallard

Aytha Valisineria - Canvasback (Map #54).

Description:
The canvasback is a member of the diving duck subfamily Aythyinae of the Anatidae. This is a distinctive duck in appearance: the male has a chestnut head, white back and sides, and black breast and rump, while the female is duller in color. Both have a characteristic long head and sloping profile.

Range:
The canvasback is one of the most numerous wintering and migrating ducks in the Chesapeake Bay area. Before a severe decline in numbers put it on the restricted list in Maryland and Virginia, it was also one of the most popular game ducks. The species is common in relatively open water areas, such as fresh and brackish river sites. The 1980 Maryland mid-winter waterfowl survey found large concentrations of canvasbacks in the Patuxent, Magothy, and Severn Rivers. On the eastern shore the Chester, Choptank, and Haza Rivers had higher concentrations of canvasbacks, as did Eastern and Fishing Bays, and the Nanticoke and Wicomico Rivers. In Virginia, major concentrations of canvasbacks occur in the lower Rappahannock, York River and Mobjack Bay, Pocomoke Sound, and the lower James and Nansemond River.

Salinity Relationships and Sensitivities:
Canvasbacks would probably only be affected by salinity changes as they would affect food distribution. The current heavy reliance of this species on Macoma balthica might render it more sensitive to low flow conditions.

Trophic Importance:

In freshwater areas submerged aquatic vegetation was the most important food source, while animal material became important in brachish areas. The pattern has apparently been modified by the recent decline in SAV's in the Chesapeake Bay. Perry and Uhler (1976) found animal material to be the most abundant food in canvasbacks killed in 1975 and 1976; Macoma balthica, a clam, was the most numerous species eaten (90%). Although nineteen species of plants were also found in these birds, they occurred in much less abundance.

The canvasback was once one of the most important game species in this area, and if numbers were restored, could again become available to the sportsman.

Selection Factors:

- Potential vulnerability to changes in food; current relatively restricted diet.
- Potential value of the species to the sport harvest, and current reduced numbers and protected status

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